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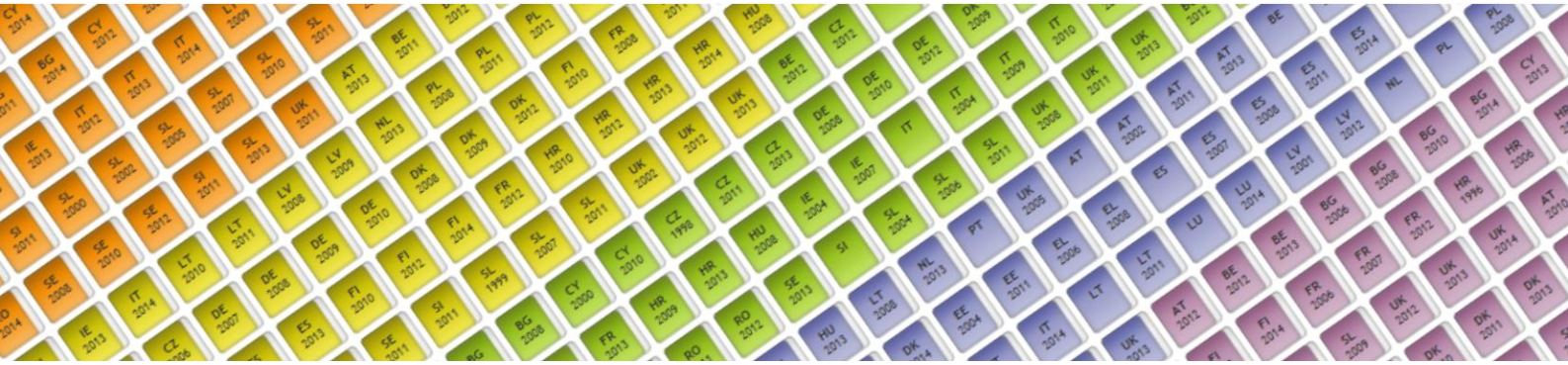

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Abstract

The report offers an analysis of the R&I system in Poland for 2014, including relevant policies and funding, with particular focus on topics critical for two EU policies: the European Research Area and the Innovation Union. The report 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 report identifies the structural challenges of the Polish research and innovation system and assesses the match between the national priorities and those challenges, highlighting the latest policy developments, their dynamics and impact in the overall national context.

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Executive summary

The report offers an analysis of the R&I system in Poland for 2014, including relevant policies and funding, with particular focus on topics critical for two EU policies: the European Research Area and the Innovation Union. The report 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 and qualitative data is, whenever possible, comparable across all EU Member State reports.

The Polish economy experiences stable economic growth and an increase of R&D-related indicators. GERD as percentage of GDP was 0.87% in 2013, which remained below the target of 1.70%, set for 2020. The R&D funded by the business sector amounted in 2013 to 0.32% of GDP (EU-28: 1.1%), but the business expenditures on R&D gradually increased in the recent years.

The Innovation Union Scoreboard 2014 placed Poland in the group of moderate innovators, identifying the following weaknesses of the Polish innovation system: low numbers of non-EU doctoral students, PCT patent applications related to societal challenges and scarce licence and patent revenues from abroad. Poland's identified strengths are: non-R&D innovation funding and intensive education efforts of the young generation.

The key developments in the RDI system in 2014 include:

- adoption of the Enterprise Development Programme (PRP), which defines the scope of public interventions in the RDI system, types of support measures and intended legal reforms,
- release of the National Smart Specialisations (KIS), listing of strategic areas for R&D,
- drafting of the operational programmes, based on the EU Structural Funds for 2014-2020, including the Operational Programme "Smart Growth" (POIR), the largest R&D funding source in Poland, and the regional programmes, which include the RDI components; the programmes undergo negotiations with the European Commission as of December 2014,
- amendments of The Act on Higher Education, facilitating the assignment of the ownership of academic inventions to individual scientists-inventors,
- amendments of the rules for "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,
- publication of the "Pact for Horizon 2020", a voluntary agreement between the Ministry of Science and Higher Education and interested PHEIs and PROs, ensuring an additional organizational support for research teams applying for funding and implementing Horizon 2020 projects, and offering co-funding to successful applicants,
- availability of numerous RDI funding programmes, including the establishment of new initiatives, involving participation of representative business communities (so-called sectoral programmes).

The national R&D target for 2020 is GERD as 1.7% of GDP. In 2013, the ratio was only 0.87% of GDP (€89.2 per capita), but the R&D statistics in Poland suffer from systematic under-reporting. The R&D funded by the business enterprise sector amounted in 2013 to 0.32% of GDP. GERD and BERD increased in recent years, and meeting the long-term targets is likely, especially with the ambitious plans to allocate a large share of the 2014-2020 EU structural funds for R&I. Share of public R&D funding distributed as grants (project funding) was 64.46% in 2013.

Poland is aligned with many ERA policies, but the RDI system suffers from its low attractiveness for foreign researchers, which can mainly be attributed to low levels of financial compensation at PROs and PHEIs. There are restrictions on access to and portability of grants compared with the ERA objectives, and HR strategy for researchers (HRS4R) enjoys only a limited popularity in Polish scientific institutions. Open access statistics demonstrate relative popularity of this mode of publishing, compared with EU-28 average, but no specific legislation incentivizes scientists to pursue open access publishing.

The Polish R&I policies tend to be synchronised with the Innovation Union objectives, and the country focuses on the promotion of knowledge transfer and science-based entrepreneurship, although tangible results of these efforts are yet to be seen. The venture capital market is thriving, but the use of innovative public procurement by the government still remains limited.

The identified structural challenges for Poland's RDI system include:

(1) Limited reporting of business investment in R&D – with low reliability of GERD and BERD data, collected by the government, and lack of adequate reaction to this challenge;

(2) Limited synergies between the science and industry, restricting the innovative potential of the economy – an area targeted by support measures and operational programmes planned for 2014-2020;

(3) A need to concentrate financial resources on key strategic areas and RDI priorities – the situation is gradually improving thanks to the definition of national and regional smart specializations in 2014;

(4) Increasing internationalization and attractiveness of RDI system – difficult to overcome due to uncompetitive compensation of scientists at PHEIs and PROs, but government efforts are focused on attracting R&D-based foreign investments;

(5) Insufficient R&D efforts of domestic and foreign-owned business enterprises – being the focus of public RDI policies, attempting to induce private co-funding of projects and to establish public-private partnerships for the development of innovations.

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1. Overview of the R&I system

1.1 Poland in the European RDI landscape

Poland is the 7th largest economy in the EU-28. With 38.49m inhabitants as of 2014 it represents 7.58% of EU-28 population. GDP per capita in 2013 was €17,500 (Purchasing Power Standard per inhabitant). The country has experienced positive GDP growth rates since the 1990s and its economy increased by 4.5% in 2011, 2.0% in 2012 and 1.6% in 2013, thus being one of the fastest growing EU-28 economies in the recent years (Eurostat, 2014). Poland's GERD was €2,836.16 in 2011, €3,429.85 in 2012, and €3,436.28 in 2013, growing by 201.7%% between 2004-2013 and by 94.8% between 2007-2013 (Eurostat, 2014). Between 2002 and 2012, GERD in Poland converted to Euro (€)[1] was increasing at an average annual rate of 11.2%, exceeding the rate for EU-28 (3.9%) (Eurostat, 2014). GERD per capita was €73.6 in 2011, €89 in 2012, and €82.2 in 2013 (Eurostat, 2014). For years 2004-2013, GERD per capita went up by 199.3%, and for 2007-2013 – by 97.7%, while GDP per capita – by 60.6% in 2004-2013 and by 28.7% in 2007-2013 (Eurostat, 2014). In spite of this increase, the indicator remains low in comparison with EU-28 average. GERD as percentage of GDP was 0.75% in 2011, 0.89% in 2012 and 0.87% in 2013, below the EU-28 average. Turnover from innovation amounted in 2010 to 8.0%, being lower than the EU average of 14.4% for 2010 (EC DGEI, 2014: 83).

1.2 Main features of the R&I system

The R&I system is still dominated by public funding, but the role of private capital increased in recent years, with business enterprises accounting for a growing share of GERD (37.3% in 2013). 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. Regions have own, relatively small, RDI budgets, supplementing the centrally distributed funds, with funds mostly allocated to innovation support and indirect support of R&D by promoting the appropriate enabling environments.

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

Figure 1 presents an overview of Poland's research and innovation system, outlining its main actors. The Parliament as the legislative body and the Cabinet (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 Economy (MG) defines the strategies related to innovativeness and supervises Polish Agency for Enterprise Development (PARP), supporting enterprises based on funds from the state

[1] 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).

budget and the EU Structural Funds, and through involvement in international projects, including COSME. PARP co-ordinates the National Service System for Small and Medium-Sized Enterprises (KSU), a network of organisations providing consulting and training services for SMEs, as well as loans and credit guarantees. 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 (agency of MG, focused on support for enterprises) and NCBiR (agency of MNiSW, focused on applied research projects), related to funding R&I in business enterprises.

The Ministry of Infrastructure and Development (MIR) defines 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. It co-ordinates the relevant activities of funding agencies.

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) started in 2014 its involvement in funding innovative projects.

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.

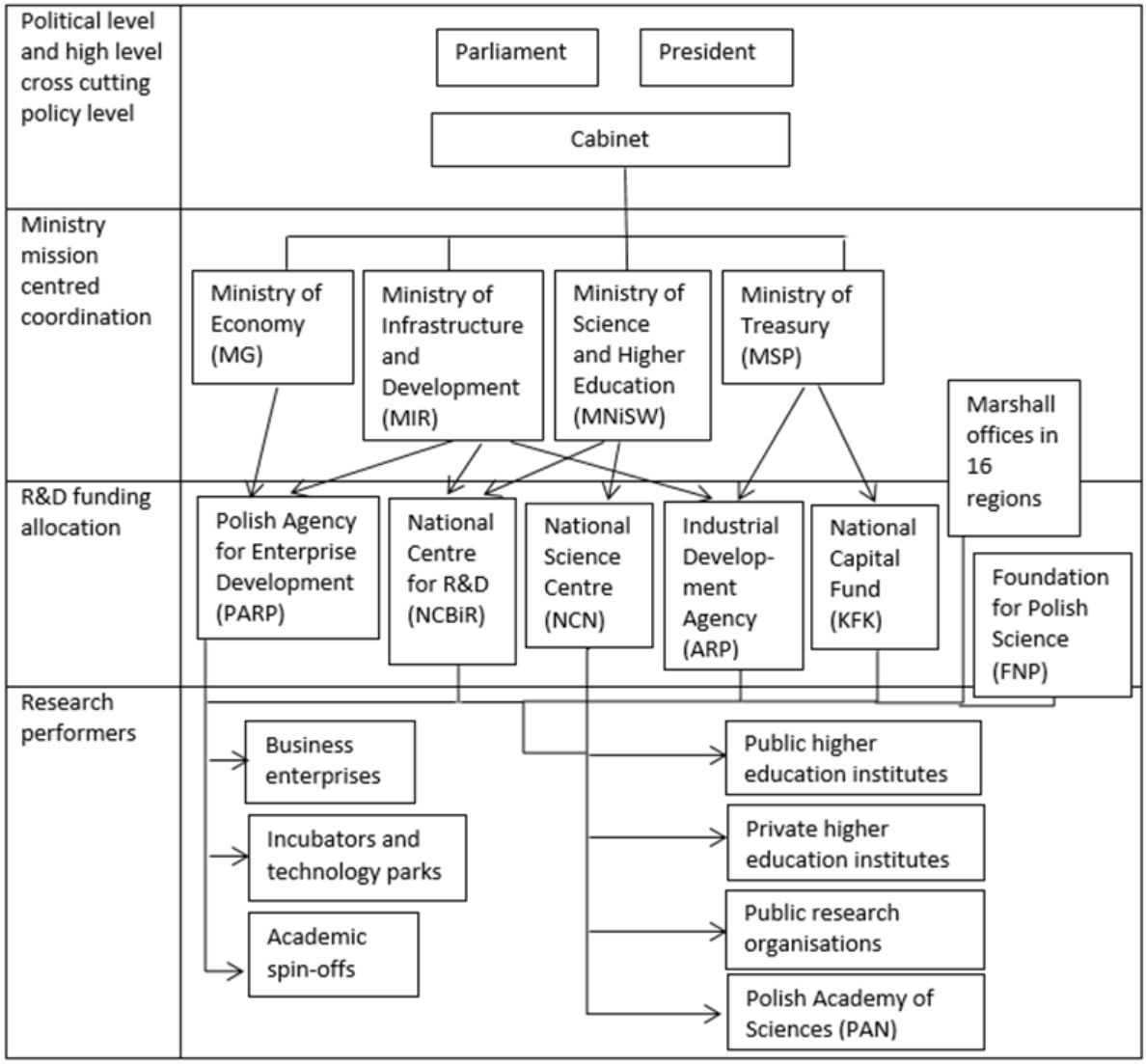
R&D performers include: Public Higher Education Institutions (PHEIs, incorporating teaching, research and technology transfer in their missions), Private Higher Education Institutions (focused mostly on education not research, with majority operating in fields of socio-economic sciences and humanities), Public Research Organisations (PROs), the large national research institution the Polish Academy of Sciences (PAN), and business enterprises. PHEIs 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. 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. 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, 2015). 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, 2015). Innovative activities of small and micro-enterprises are rarely included in the official R&D statistics, but a thriving community of high-tech start-ups exists in Poland, benefiting from incubators, accelerators and public co-funding.

The 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.

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.

Figure 1. Poland's RDI governance system



The Key developments in Poland's RDI system in the recent five years included: carrying out the National Foresight Programme (2009), the launch of a wide ranging legislative and institutional reform of science (2010) and higher education sectors (2011), combined with the establishment of NCN as fundamental research agency and empowering NCBiR to distribute large-scale funding for applied R&D projects (2010). The government adopted

the National Research Programme (KPB, 2011), defining strategic directions for R&D funding, and established the Polish Roadmap for Research Infrastructures (PMDIB, 2011). Based on the strategic R&D directions, defined in the National Research Programme, as well as analytical studies and broad consultations with stakeholders, NCBiR launched in 2013 multiple new funding programmes, targeting R&D funding gaps in areas such as innovative medicine, environmental technologies, non-ferrous metals, aviation technologies, graphene and shale gas exploration. In 2013-2014, an underlying framework for business enterprises and science-industry co-operation was established with the Strategy for Innovation and Efficiency of the Economy (SIEG), the Enterprise Development Programme (PRP), National Smart Specialisations (KIS) and draft Operational Programmes, defining public interventions based on the EU Structural Funding, 2014-2020 (including the Operational Programme "Smart Growth", POIR, as the main RDI-related investment programme). In 2014, 16 Polish regions defined their smart specializations, and new legal framework for commercialization of university research results was introduced, facilitating the transfer of the ownership of IPRs to scientists-inventors.

Main Changes in 2009
National Foresight Programme *Government announcing plans for a wide-ranging science and higher education reform and increase of the science budget*
Main Changes in 2010
Legislative reform of the science sector *Establishment of NCN (fundamental research funding agency)* *Empowerment of NCBiR (applied R&D funding agency)*
Main changes in 2011
Legislative reform of the higher education sector *Adoption of the 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 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 the Enterprise Development Programme (PRP) and National Smart Specialisations (KIS) *Definition of smart specialisations by 16 regions* *Relaxation in 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*

2. Recent Developments in Research and Innovation Policy and systems

2.1 National economic and political context

The Polish economy was spared in the Eurozone crisis, but the GDP growth in 2013 was slower than expected, and initial economic expectations for 2014 were low. In consequence, the state budget was amended in August 2013, with a minor reduction of the funds earmarked in the science (R&D) budget. The cuts affected spending by NCBiR and NCN, but were not alarming, due to the fact that in 2012, both institutions did not manage to spend proportionally higher shares of their budgets than the reductions in 2013. The actually executed science budget in 2013 amounted to 98.76% of the allocations from 2012, and further cuts were planned for 2014, as the science budget for 2014 was 96.99% of the funding available two years earlier. Nevertheless, the budget for 2015 foresees a substantial increase in public expenditures both on science (10,25%) and higher education (about 6%). The 2015 science budget will amount to €1,747m and be the highest in the history of Poland. In addition, Poland plans raising its defence expenditures due to the geopolitical situation, and a large share of this spending will involve R&D.

The GDP growth in 2014 was positive and despite the observed slowdown, Poland maintained one of the highest GDP growth rates in the EU. In 2013, Poland was the 9th most popular EU destination for foreign direct investments according to a report by Financial Times (fDi Intelligence, 2014: 6).

The Polish Prime Minister Donald Tusk was elected president of the European Council, and the deputy prime minister Elżbieta Bieńkowska, who used to be in charge of regional development, including distribution of EU structural funds for RDI, became the European Commission's commissioner for internal market, industry, entrepreneurship and SMEs. Paradoxically, the leaders' departure to a prestigious post in Brussels strengthened the position of the ruling centre-right party Civic Platform (PO) and the agrarian Polish People's Party (PSL). In October 2014, a new government was sworn and the opening speech of the new Prime Minister Ewa Kopacz presented the plans to: raise R&D expenditures to 2% GDP by 2020 (higher than the existing commitment of 1.7% GDP); substantially increase defence spending in 2016, with new technological military investments, which would help "build innovative potential of the Polish defence industry"; more actively use public support to boost export performance of SMEs; and stimulate investments of business enterprises by increased availability of credits through the state bank BGK. Ministers of Economy and of Science and Higher Education remained unchanged in the new government, thus ensuring the continuity of operations.

In July 2014, the Parliament adopted amendments to legal acts, concerning science sector and higher education, which built the basis of the 2010-2011 reform of the sector, initially intended to stimulate the competitiveness, innovativeness and science-industry co-operation. The changes from 2014 included tweaks necessary to correct earlier legislative shortcomings, but a part of the present reform was also a heavily disputed topic of assigning the ownership of IPRs to the employees of public universities and Polish Academy of Sciences.

In November 2014, the Industrial Development Agency (ARP) initiated its involvement in RDI support, by announcing plans to invest a substantial budget in 2015-2020 to support the innovativeness of the Polish economy. ARP is an agency of the Ministry of Treasury, which traditionally supported the privatization and reorganization processes of large state-owned enterprises, but in recent years ventured into new areas (including financial support for graphene development projects). In particular, ARP plans to offer financial instruments, including loans to support participation of Polish organisations in the EC Framework Programmes and VP-type involvement in innovative SMEs. These ideas were presented as part of ARP's new strategy, and still need to be operationalized in the coming months.

Throughout the year of 2014, Poland was negotiating with the EC its Operational Programme Smart Growth (POIR), based on the EU Structural Funds, intended to support RDI, focused on the development of technologies rather than their implementation, and the principles of smart specialization. The preparations of POIR in 2013 involved broad inter-governmental and public consultations and critical evaluation of previous support measures. Parallel processes take place in all 16 regions, negotiating and amending their Regional Operational Programmes (RPOs).

2.2 National R&I strategies and policies

R&I policies enjoy high-level political support of the Council of Ministers and the President, based on a multi-annual strategy with assigned budgets, both from the state budget and the EU Structural Funds. The strategic framework consists of:

- SIEG (Strategy for Innovation and Efficiency of the Economy), adopted in 2013 as the top-level policy document;
- PRP (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 listing 18 strategic areas for RDI, 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 (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 (Polish Roadmap for Research Infrastructures), updated in 2014, consisting of large-scale RI initiatives, recommended for public support;
- POIR (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 (defined until 2020) includes 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 key challenges of the RDI system, including: stimulation of private expenditures on R&D, internationalisation and innovativeness. Quantitative targets, set by SIEG, include: GERD to GDP ratio of 0.93% in 2015 and 1.70% in 2020 (RM, 2013a: 89). 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),
- 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-emphasizing 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 internships 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. The above-presented documents are integrated, with hierarchically structured system of objectives/priorities, consistent with most of the EU priorities in RDI area, elaborated co-operatively by multiple governmental institutions, and adopted by the Council of Ministers. The policy and budgetary framework is predictable and stable. 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.

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 and R&D activities. Separate plans exist for higher education and lifelong training, but they benefit from inter-linkages with R&D 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. Fundamental research is supported through different modalities than applied R&D, ensuring continuous development of the necessary knowledge base. 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.

Funding for RDI was not reduced in spite of the economic downturn of the recent years (with only minor adjustment in the middle of 2013), the science budget in 2015 will increase by over 10%, and POIR will be the source of additional, substantial funding for RDI efforts. 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. RDI policies were drafted and improved through a broad social consultation process, involving relevant, non-governmental stakeholders. The framework relies on progress monitoring by using output indicators, ex-ante and ex-post evaluations. Polish government operates with activity-based budgets, and annual budgetary plans include specific quantifiable objectives, with detailed targets in RDI area, thus stimulating a regular verification of targets and actual performance. The Main Statistical Office (GUS) maintains an online policy monitoring system "STRATEG" for the use by policy makers, with regularly collected indicators supporting policy implementation, including indicators in the RDI area.

Among the RDI funding, the EU Structural Funds play an important role, and the process of drafting operational programmes for 2014-2020 catalysed broad debates about the economic importance of innovations and strategic focus (interpreted as smart specialisation strategies on the national and regional levels). Poland uses joint-programming opportunities by co-funding participation of Polish researchers in trans-national projects, spending on these cross-border initiatives more than any other new member state. POIR includes plans to further expand this type of support, in order to benefit from complementarities and synergies between national instruments and Horizon 2020. Research infrastructures are funded through dedicated programmes, with the largest initiatives forming part of the national roadmap PMDIB, and financial support for RI is foreseen by POIR and some RPOs.

Main R&I policy initiatives from 2014 are described below:

- The Council of Ministers adopted policy documents PRP, KIS, POIR and RPOs, as described earlier in the chapter.
- 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.

- The Parliament amended the Act on Public Procurement, which simplifies purchasing procedures at PHEIs and PROs, by freeing them from standard public procurement routes if the order value is lower than €207k (the level was €14k before). Public procurement regulations no longer apply to research services, results of which would be openly shared with the public. Moreover, public procurement results could be easily nullified if the organisation was denied R&D funds, which were allocated to finance the order in question.
- 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. 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 Council of Ministers amended the rules for "Programme for Supporting Investments of Major Importance to the Polish Economy for the Years 2011–2020", which offers grants to large investors, mostly FDIs. The amendments include incentives for R&D investments, and investors from priority sectors (automotive, electronics, aviation, biotechnology, business services sector).
- The government drafted several strategic documents, with relevance to RDI policy, including: 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), "Package for Humanities" (reconfirming public support for humanities and social sciences), "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), and programme for protection of copyrights (prepared by the Ministry of Culture and National Heritage, including planned activities to promote IPR management).
- The Parliament amended The Act on Higher Education, 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 fails to commercialize an invention within 3 months following its disclosure by inventors to the institution. In order to transfer the IPRs, academic inventors will only 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 traditionally belong 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.

Nevertheless, the move could increase the involvement of scientists and stimulate the science-industry co-operation.

Table 1 lists the main research programmes, funded in 2013 by NCN, NCBiR and MNiSW, including their annual executed budgets (covering both grants newly awarded grants in 2013, as well as projects continued in 2013 but initiated in previous years).

Table 1. Major R&D funding programmes and their budgets in 2013

Name of programme	mln EUR[2]	Funding agency	Description
Fundamental research			
OPUS	80.20	NCN	large projects, usually for experienced researchers
MAESTRO	21.01	NCN	the most experienced researchers
SONATA	20.67	NCN	recent PhDs
PRELUDIUM	16.52	NCN	doctoral candidates
HARMONIA	10.13	NCN	international collaborative projects
IUVENTUS PLUS	10.59	MNiSW	young researchers
SONATA BIS	7.33	NCN	researchers 2-12 years after PhD
National Programme for Development of Humanities	5.20	MNiSW	large projects in humanities and social sciences
IDEAS PLUS	2.26	MNiSW	finalists of ERC programme IDEAS, who were not granted ERC support
FUGA	2.24	NCN	recent PhDs
ETIUDA	1.96	NCN	doctoral candidates
SYMFONIA	0.50	NCN	the most experienced researchers
Applied research, development and innovation			
POIG 1	265.37	NCBiR	applied R&D, based on EU Structural Funds (including POIG 1.4, DEMONSTRATOR+, INNOLOT)
POIG 2	202.81	NCBiR	research infrastructure, based on EU Structural Funds
Defence	71.72	NCBiR	defence R&D
PBS	54.57	NCBiR	generic applied R&D
INNOTECH	50.17	NCBiR	development of innovative technologies
Advanced energy generation technologies	15.48	NCBiR	energy
Polish-Norwegian Research Cooperation	13.36	NCBiR	applied R&D
LIDER	6.88	NCBiR	applied R&D for young researchers
BLUE GAS	6.41	NCBiR	shale gas
GRAF-TECH	4.58	NCBiR	graphene
Safe nuclear energy	4.31	NCBiR	nuclear energy
Creator of innovativeness	2.31	NCBiR	technology transfer centres at PHEIs
Mining safety	1.28	NCBiR	mining
SPIN-TECH	1.18	NCBiR	technology transfer companies of PHEIs and PROs
GO_GLOBAL.PL	0.96	NCBiR	international expansion of technology companies
BRIDGE	0.62	NCBiR	commercialization of scientific research
Energy efficiency of buildings	0.45	NCBiR	construction
PATENT PLUS	0.35	NCBiR	IPR protection

Source: MNiSW budgetary report, 2013

[2] Budgetary data for 2013 converted from PLN to Euro using the rate 1€ = 4.1472 PLN (annual exchange rate, published by NBP).

New funding programmes, launched by NCBiR in 2013-2014, and not included in the 2013 budget, were: TANGO (supporting follow-up applied research based on results from other NCN-funded projects), "Innowacje Społeczne" (social innovations), GEKON (environmental technologies), RID (transport technologies), CuBR (non-ferrous metals) and INNOMED (innovative medicine). In 2014, NCBiR signed agreements with VC partners to expand its programme BRIdge by creating a public-private RDI funding initiative, in which funding from VCs will be combined with the public sources to invest in technology-intensive firms, and different types of investments are foreseen depending on the stage of technology development.

R&D funding is divided between generic funding, not assigned to specific thematic priorities, and specialized R&D funding programmes, which have mushroomed in recent years. A significant part of funds for applied R&D, distributed by NCBiR, is clearly focused on specific research themes. There are numerous dedicated funding programmes, including humanities and social sciences, medical or pharmaceutical innovations, defence R&D, shale gas, environmental technologies, and graphene-based innovations. The EU Structural Funds for 2014-2020 will be distributed, taking into account regional and national smart specializations strategies/objectives, and this shall further increase the thematic focus. POIR will include support for "sectoral programmes", offered by NCBiR to target specific technology types, with themes and types of interventions defined jointly with representative business associations in a way resembling the model of "entrepreneurial discovery process".

Table 2. Shares of public funding (GBAORD) allocated in 2013 for specific thematic priorities, according to NABS-2007 socio-economic objectives

NABS code	Thematic priority	Poland	EU-28
NABS01	Exploration and exploitation of the earth	3.4%	2.0%
NABS02	Environment	5.9%	2.6%
NABS03	Exploration and exploitation of space	2.4%	5.2%
NABS04	Transport, telecommunication and other infrastructures	6.6%	2.7%
NABS05	Energy	2.2%	4.1%
NABS06	Industrial production and technology	11.1%	9.2%
NABS07	Health	14.8%	8.8%
NABS08	Agriculture	4.9%	3.3%
NABS09	Education	4.3%	1.2%
NABS10	Culture, recreation, religion and mass media	0.8%	1.1%
NABS11	Political and social systems, structures and processes	0.7%	2.8%
NABS12-13	General advancement of knowledge	37.7%	52.6%
NABS14	Defence	5.2%	4.6%

Source: Eurostat

The comparison of GBAORD distribution among specific thematic priorities proves that the Polish R&D funding is more focused than the EU-28 average, with a significantly smaller share allocated for general advancement of knowledge than in other countries. Poland assigns relatively higher funds to themes, which are consistent with some of the societal challenges, identified in Horizon 2020[3], by strongly supporting research related to health

[3] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges, access date: February 2015

(14,8% compared with 8,8% EU-28 average), agriculture (4,9%; EU-28: 3.3%), transport (6.6%, EU-28: 2.7%) and security (5.2%, EU-28: 4.6%). R&D related to climate action, environment and resource efficiency amounts to 5.9% of GBAORD (EU-28: 2.6%), and while targeted energy research is relatively smaller (2.2% compared with EU-28: 4.1%), EU funding for 2014-2020, based on POIR and RPOs, will have substantial funds earmarked for climate-related R&D investments, as determined by the Partnership Agreement between Poland and the EC. In addition, many relevant investments co-funded by the government environmental agency NFOŚiGW are not counted towards R&D appropriations even though they might meet the criteria from "Frascati Manual" (comp. section 2.5.1 of this report). The smaller than average share of appropriations for humanities is likely to increase, based on a plan announced by MNiSW in 2014, called "Package for humanities" ("Pakiet dla humanistyki"). The societal challenges are also adequately matched by the identified national smart specialisations (KIS), ensuring continuity of funding in these areas.

The above-described policy measures emerged from multiple parallel processes, sometimes without an adequate integration between measures, or involving incoherent bottom-up approaches. Starting from 2013, they are combined into one strategic perspective, with top level policy documents and implementation plans, including PRP, POIR and RPOs. Experiences gained during the experimentation stage were used to support the design of R&I funding instruments for 2014-2020, and the new policy framework offers adequate integration, coherence and strategic orientation.

2.3 National Reform Programmes 2013 and 2014

NRP 2013 emphasized the importance of further investments in RI, commitments to continuously improve the quality of higher education and to the "upskilling of Polish R&D sector staff, including also the employees of companies carrying out activities in the field of R&D" (RM, 2013b: 20). The document reported main measures and policies relevant to R&I, which were enacted in 2012 (RM, 2013b: 21-22), emphasizing the importance of funding applied research and commercialization of research results, and linking the efforts to the main policy document SIEG. For the year of 2013, it set target GERD at the level of 0.83% GDP (RM, 2013b: 21), while the actual GERD exceeded this target and amounted to 0.90% of GDP (but was later revised to 0.89% GDP, as Poland's GDP increased due to the ESA 2010 methodology in 2014).

Main actions planned for 2013-2014 included:

- the introduction of PRP to establish a comprehensive, systematic approach to supporting business enterprises,
- the implementation of support measures in operational programmes, distributing the EU Structural Funds, 2014-2020,
- further work on financing RI, including earmarking of funds for projects included in the PMDIB update,
- calls for proposals in numerous R&D funding programmes,
- identifying a list of technology and research areas, considered national smart specialisations,

- funding research commercialisation through measures targeting researchers and scientific institutions (RM, 2013b: 24-28).

The above-listed efforts were indeed enacted by the government, and they can be considered beneficial for further development of the Polish R&D system, as described in other chapters of the report. The government committed also to the introduction of the 1% corporate tax deductions, which would be used to fund scientific institutions, "during the first year after removing Poland from the scope of excessive deficit procedure" (RM, 2013b: 24), but the condition could not be satisfied in 2013 or 2014, and the declaration was not followed-up by the necessary legislative efforts.

NRP 2014-2015, adopted in April 2014 and covering two consecutive years, emphasizes 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: 24).

Some activities foreseen for 2014-2015 could not really be considered reform plans, as they refer to activities, which were initiated before NRP was drafted:

- establishment of a support system for business enterprises, distributing the EU Structural funds (RM, 2014a: 27), and continuity of operations of KSI (the National Innovation Network) and KSU (the 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 are:

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 (RM, 2014a: 31-32),
3) an update and follow-up implementation activities for the industrial technology foresight project "InSight 2030" by the 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 the 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).

Activities (1), (2) and (3) were implemented, but the remaining activities were not carried out in 2014. The Programme comes short of declaring specific activities related to the introduction of R&D tax reliefs, which were recommended by CSR for Poland in 2013 and 2014. It refers to the opinions of social partners, who supported this fiscal mechanism in the course of public consultations of government policy documents, but explains 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 delivers on most of the promises from NPRs in the area of RDI, there is a demonstrable inactivity in the area of tax policies for RDI.

2.4 Policy developments related to Council Country Specific Recommendations

The Council of the European Union adopted in 2013 Country Specific Recommendations (CSR), relevant for R&I policy in Poland (CEU, 2013). Poland was identified as "one of the worst performers in broader innovativeness indicators" (CEU, 2013: 7), with very low levels of GERD and BERD. The recommendations were based on data for 2011, while both indicators significantly increased in 2012). The Council noted the past reliance of Polish business enterprises on technology absorption (defined as "application of already existing technologies through fixed capital investment"), which needs to be replaced by development of new technologies ("a transition towards a more indigenous innovation-based model") (CEU, 2013: 7). The statement is an adequate summary of the government policies, as the main R&I-related funding programme for the EU Structural Funds for 2007-2013 (POIG) was indeed focused on technology absorption, intended to facilitate the catch-up of Polish companies with their foreign competitors by supporting access to new technologies, as well as improving the research infrastructures, which had been dramatically under-invested before. The programming of the funds for 2014-2020 in Poland was guided by an explicitly stated shift in focus, coherent with the Council's remarks: the new operational programme (POIR) will primarily support development not absorption of technologies, and the broad consultations, which supported the drafting and further modifications of the Programme, helped promote this shared vision among stakeholders.

Interestingly, when comparing the diagnosis with the contents of CSR'2012, one could note that the Council was no longer explicitly concerned that Poland could not meet its national target (GERD to GDP ratio) by 2020, but instead appreciated the recent science and higher education reform as it "initiated a major restructuring to induce science-industry cooperation" (CEU, 2013: 7).

CSR from 2014 repeated the framing interpretations presented above, pointing 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 insight into the updated interpretation of Poland's progress in RDI 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). While the CSR review multiple policy documents and support programmes, many of which were adopted to address recommendations from CSR 2013, they also contain a statement that "the innovation and R&D support framework is fragmented and requires substantial further investment" (EC, 2014: 4).

The Council urged Poland in 2013 to: (1) strengthen the linkages between R&I and industrial policy, (2) nurture the application of revolving instruments and tax incentives to stimulate business R&D, (3) better adjust the support instruments to different stages of the innovation cycle (CEU, 2013: 10).

The first of these recommendations was considered no longer relevant in 2014, in light of the recent policy developments: adoption of Enterprise Development Programme (PRP), offering comprehensive R&D support framework and defining national smart specializations (KIS); preparation of the Operational Programme Smart Growth (POIR), which focuses primarily on development and commercialization of new technologies; success of NCBiR in substantially increasing the private investments in R&D projects through public co-funding (EC, 2014: 24). Summarizing the reforms from 2013-2014, the EC expressed the view that "taken together, the changes are comprehensive and consistent in their approach. Implementation will show how effective they are. Unless the Enterprise Development Programme is implemented effectively, progress in addressing the relevant recommendation will remain limited" (EC, 2014: 24).

RDI-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).

Recommendation (1) remains unanswered by the Polish government. The existing tax regulations do not really incentivize 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 Programme 2014-2015, mentioning that R&D tax breaks are expected by

stakeholders but failing to list any relevant activity planned for the years of 2014 and 2015 (comp. section 2.3 of this report).

Recommendation (2) emphasizes 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 was 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"). R&D-related measures will be managed by NCBiR to avoid competence overlaps among government agencies, and NCBiR also signed agreements with several regional governments to support the management of the regional R&D programmes.

2.5 Funding trends

2.5.1 Funding flows

The national R&D investment target is GERD as 1.7% of GDP by 2020, and BERD accounting for half of GERD. The government projections of gross domestic expenditures on R&D for the coming years were: 0.91% of GDP in 2013, 0.93% of GDP in 2014, and 1.02% of GDP in 2015 (RM, 2014b: 24). In her opening speech in October 2014, Poland's new prime minister declared the intention to raise the GERD target to 2.0% of GDP by 2020.

GERD and BERD increased in recent years[4], and meeting the targets is likely thanks to the planned, broader availability of public funding for R&D (including EU Structural Funds for RDI). 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.

[4] Poland's GERD was: 0.67% of GDP in 2009, 0.72% in 2010, 0.75% in 2011, 0.89% in 2012 and 0.87% in 2013, and GERD per capita: 55€ in 2009, 68.3€ in 2010, 73.6€ in 2011, 89€ in 2012 and 89.2€ in 2013. BERD in relation to GDP was: 0.19% in 2009, 0.19% in 2010, 0.23% in 2011, 0.3% in 2012 and 0.38% in 2013. Despite the constant increase of BERD, its value seems underreported as described later in this sub-chapter. Statistics were revised due to the inclusion of ESA 2010 methodology in GDP accounting in 2014, resulting in an increase of GDP and related changes of GDP-based indicators.

The consulting company KPMG prepared in 2013 their own forecast, stating that GERD in 2020 was more likely to be at the level of 1.60% of GDP than 1.70% (KPMG, 2013: 41), but no methodological foundations of the forecast were explained, and the report was published before the release of new GERD data for 2012 (demonstrating substantial year-to-year growth), and before the new publicly funded RDI support measures for 2014-2020 were designed.

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).

The EU economic slowdown had no direct impact on Polish R&D data, and minor adjustments of Poland's science budget in 2013 and 2014 did not negatively affect the RDI funding programmes. Business enterprises reported significant increases in R&D spending in the worst years of the Eurozone crisis. According to a survey carried out by KPMG in 2013, 62% of large and medium companies planned to increase the scale of their R&D efforts in three following years (KPMG, 2013: 34), 24% of the surveyed companies intended to spend on R&D 6% or more of their revenues (KPMG, 2013: 23), and 32% planned to commission R&D projects to be performed by HEIs or PROs (KPMG, 2013: 35).

The main problem of GERD statistics in Poland is their systematic underreporting, which can be attributed to 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. BERD figures for 2013 were compiled from forms submitted only by 2,127 business enterprises (GUS, 2014b).

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.

Yet another example of possible under-estimation of R&D expenditures is related to specialist public funding, allocated to projects in the areas of health, energy and environment. For example, the National Fund for Environmental Protection and Water Management (NFOŚiGW) manages multiple programmes, co-financing investments in environmental technologies, renewables and energy efficiency. Many of projects funded by NFOŚiGW include R&D efforts, but most are never accounted for as R&D due to the lack of awareness of beneficiaries from public and private sector, even though the projects satisfy the methodological requirements set in "Frascati Manual" by OECD. The planned budget of NFOŚiGW for 2014 is approximately €139m, and for 2015: over €125m (RM, 2014b: 42), but the own funds of NFOŚiGW are supplemented by substantially higher budgets based on the EU Structural Funds, devoted to environmental investments. Beneficiaries of these funds have no specific obligations to report R&D expenditures, which could be e.g. linked to project selection criteria or compulsory evaluations. Similar problems concern several large-scale programmes in the area of health and medicine, managed by the Ministry of Health.

Table 3. Basic indicators for R&D investments

	2009	**2010**	**2011**	**2012**	**2013**	**EU28 (2013)**
GDP growth rate	1.60%	3.90%	4.50%	2.00%	1.60%	0.10%
GERD (% of GDP)	0.67%	0.72%	0.75%	0.89%	0.87%	2.02%
GERD (euro per capita)	55.0	68.3	73.6	89.0	89.2	539.2
GBAORD - Total R&D appropriations (€ million)	1,051.67	1,313.59	1,175.14	1,370.13	1,438.38	90,505.61
R&D funded by Business Enterprise Sector (% of GDP)	0.18%	0.18%	0.21%	0.29%	0.32%	1.1% (2012)
R&D funded by Private non-profit (% of GDP)	0%	0%	0%	0%	0%	0.03% (2012)
R&D funded from abroad (% of GDP)	0.04%	0.09%	0.1%	0.12%	0.11%	0.2% (2012)
R&D related FDI (*) (€ million)	300.79	303.53	388.22	525.14	694.17	n/a
R&D performed by HEIs (% of GERD)	37.07%	37.19%	35.10%	34.43%	29.26%	23.19%
R&D performed by Government Sector (% of GERD)	34.31%	35.90%	34.53%	27.96%	26.83%	12.21%
R&D performed by Business Enterprise Sector (% of GERD)	28.50%	26.63%	30.13%	37.21%	43.62%	63.76%
Share of project vs. institutional public funding for R&D	44.63% / 45.98%	48.36% / 33.54%	57.55% / 31.81%	63.61% / 32.94%	64.46% / 30.33%	n/a
Employment in high- and medium-high-technology manufacturing sectors as share of total employment	4.8%	4.6%	4.8%	4.9%	5.0%	5.6%
Employment in knowledge-intensive service sectors as share of total employment	29.5%	30.1%	30.0%	30.6%	31.2%	39.2%
Turnover from innovation as % of total turnover	9.8% (2008)	8.0%	n/a	n/a	n/a	13.4% (2010)

Data sources: EUROSTAT, October 2014; the Ministry of Science and Higher Education; GUS; (*) data for R&D expenditures of business enterprises with predominance of foreign capital (GUS).

Table 3 presents the key R&I funding indicators for Poland, outlining their continuous improvements, albeit happening at a slow pace. The science and higher education reforms from 2010-2011 are likely to generate further increases in the coming years, by encouraging the involvement of the private sector in R&D activities. Already in the first year after the reform, GERD to GDP ratio went up from 0.76% in 2011 to 0.90% in 2012, and BERD as percentage of GERD rose from 30.13% in 2011 to 37.21% in 2012. These changes were accompanied by the decrease of the share of GERD funded by the government, alongside with the strong shift of public funding towards competitively selected R&D projects. Minor decreases in science budget in 2013 and 2014 did not have noticeable impacts on the R&D activities, as the majority of funds distributed by NCBiR and NCN were spared these cuts. The importance of private sector as source of R&D funding increases, and is likely to further raise if the BERD data collection problems are addressed, as explained in preceding paragraphs.

Poland covers a relatively small share of its GERD from EU Framework Programmes, relying more on the EU Structural Funds. Total financial contribution of the European Commission to beneficiaries of the 7th Framework Programme from Poland amounted to €442.1m, and was distributed among 1,728 projects with 2,222 Polish participants[5]. R&D expenditures covered by 7FP in Poland were: €62m in 2010, €77m in 2011 and €68m in 2012. MNiSW started in 2014 promoting active participation of Polish organizations in Horizon 2020, by offering government co-funding of successful applications and strengthening the national and regional structures of contact points, offering the applicants unpaid support services.

Interestingly, the importance of the EU Structural Funds for R&D seems to be over-rated in popular interpretations, as the total funding for R&D from this source is actually much smaller than the R&D expenditures of foreign companies operating in Poland, or budgets of government-funded R&D programmes. For example, in 2012 the EU funding for R&D in Poland amounted to €373.26m (including €68m from the 7th Framework Programme), while foreign-owned enterprises incurred €525.14m R&D expenditures, and the total GBAORD was €1,370.13m.

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[6], but these allocations cover not only R&D but also other innovation-related funding. Apart from the co-funding for R&D, the EU Structural Funds in Poland have a broader impact on innovation, particularly in the private sector. Many support measures are geared towards business enterprises, encouraging specialised training, commercialisation and implementation of new technologies, supporting patenting, and stimulating international expansion of innovative companies. Significant EU funding from the 2007-2013 perspective was also allocated to research infrastructures, mostly at PHEIs and PROs, and recent legislative efforts stimulated the use of these RI by business enterprises, including new innovative companies.

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 foreign R&D

[5] Source: RIO elaboration of DG RTD CORDA database
[6] Source: RIO elaboration of DG REGIO data

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" (comp. sub-chapter 2.2). The registered increase in R&D funding from foreign investors in 2012 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 a dedicated fund to support the commercialization of R&D-based companies, Pitango Investin Ventures.

The data on R&D of foreign affiliates, collected by GUS based on annual R&D survey, differ from the data available from Eurostat[7]. Polish national statistics indicate that foreign-owned enterprises spent on R&D €388.22m in 2011 and €525.14m in 2012, while Eurostat registers only €196.4m 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).

Poland assigns significant public funding to transnationally coordinated R&D: €41.413m in 2012 and €44.479m in 2013. The amount is close to the transnational funding 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 European Space Agency (ESA) since the first calls for proposals became available to Polish applicants in 2013.

2.5.2 Project vs. institutional allocation of public funding

A comprehensive legal reform of R&D financing system was introduced in 2010-2011, and brought forward positive results in the following years. 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 2014, minor amendments were made to the relevant legal acts, taking into accounts lessons learned from the first years after the reform, but they did not affect the underlying financing framework.

Project funding is distributed by dedicated agencies: NCN (basic research), NCBiR (applied research), PARP (private sector RDI projects), with some programmes also managed by MNiSW and other government bodies, as well as FNP (non-government foundation, acting as an umbrella organisation, distributing public funds in combination with own financial resources). 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

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

organisations and was one of major achievements of the 2010-2011 reform, but is still criticized by some representatives of PHEIs and PROs.

Institutional funding is allocated by MNiSW, based on the outcomes of institutional assessments, co-ordinated by KEJN. The balance between project and institutional funding evolved in recent years, as Table 3 demonstrates. Before the 2010-2011 reform, institutional funding was dominant in the science budget, while in 2013, 64.46% of the government R&D budget were distributed through competitive calls for proposals, and 30.33% - allocated based on the outcomes of institutional assessments. According to the planned budget for 2014, 61.16% corresponds to project funding and 31.90% 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 (54.25% in 2012, 56.68% in 2013, 52.29% planned for 2014).

R&I funding in the recent years included substantial investments in research infrastructure, needed to catch up with foreign R&D performers. As a result, the degree of consumption of research equipment dropped from 75.2% in 2010 to 71.5% in 2012 (GUS, 2014a: 58).

Institutional funding

Institutional funding is allocated based on the outcomes of nation-wide institutional assessments, using criteria defined by KEJN (the Committee for Evaluation of Scientific Research Institutions), 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.

Based on the outcomes of the evaluation, organizations fall into specific research categories 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).

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. 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 will disappear 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.

Project funding

Funds for R&D are allocated by NCN (the National Science Centre, funding agency for basic research) and NCBiR (the National Research & Development Centre, funding agency for applied research), as foreseen by the 2010-2011 science reform. Small R&D budgets are still distributed also by FNP (the Foundation for Polish Science, offering financing for projects based on a mixture of government and own financial resources), MNiSW (the Ministry of Science and Higher Education) and PARP (the Polish Agency for Enterprise Development).

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. Funding programmes by NCN are: OPUS (large projects, usually for experienced researchers), PRELUDIUM and ETIUDA (targeted at doctoral candidates), SONATA and FUGA (available for recent PhDs), SONATA BIS (for young researchers, 2-12 years after being awarded a doctoral degree), HARMONIA (supporting international collaborative projects), MAESTRO and SYMFONIA (destined for the most experienced researchers), TANGO (supporting follow-up applied research based on results from other NCN-funded projects).

NCBiR manages multiple applied 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. For all programmes, applications go through peer-review processes 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.

Main funding programmes by NCBiR can be divided into:

- Strategic programmes – 7 large-scale initiatives in areas, identified in the "National Research Programme" (KPB), an official government policy document from 2011, which will probably be superseded by the more recent "National Smart Specializations" (KIS), and include among others programmes targeting life sciences, advanced materials and new energy generation technologies;
- National programmes open to applicants from all scientific and technological areas – including: PBS (the largest nation-wide applied R&D competition), POIG 1.4 (similar to PBS, but based on EU Structural Funds), DEMONSTRATOR+ (supporting the development of prototypes and first implementations of technologies), PATENT PLUS (co-funding IPR protection), INNOTECH (financing the development of innovative technologies by co-operation between science and industry), LIDER (applied R&D projects managed by young researchers), BRIdge (support for commercialization of scientific research, involving VC partners in a public-private partnership mode), GO_GLOBAL.PL (helping innovative companies expand their activities in Silicon Valley and Western Europe), TANGO (described above as a joint NCN-NCBiR initiative);
- National programmes targeting specific types of technologies or industries – including: BLUE GAS (shale gas technologies), CuBR (non-ferrous metals), GDDKiA (transport technologies), GEKON (environmental technologies), GRAF-TECH (graphene), "Innowacje Społeczne" (social innovations), INNOLOT (aviation industry), INNOMED (innovative medicine);
- Programmes for defence sector;
- International programmes – with NCBiR co-funding participation of Polish research teams in transnational initiatives including EUREKA, EUROSTARS, ERA-NETs and multiple bilateral funding schemes.

In the new financial perspective 2014-2020, NCBiR will manage the R&D support measures based on the EU Structural Funds, and already prepares a set of "sectoral programmes", which will correspond to National Smart Specializations and be defined in accordance with the principles of the entrepreneurial discovery process, with a substantial involvement of representations of business companies and differentiated focus of public interventions, depending on the identified needs of the R&D performers from a specific sector. The design of sectoral programmes will be flexible, allowing launches of new programmes based on needs demonstrated by representative groups of companies, willing to co-fund the initiative.

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).

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 selected proposal. 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.

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. NCBiR streamlined its procedures related to the evaluation of applications, and in 2013-2014 assured that funding decisions concerning business enterprises, applying for R&D funding, were made within 60 days. The reliance on the core principles of peer-review is also required for all R&D funding distributed based on the new operational programme for 2014-2020 (POIR).

Other allocation mechanism

Apart from the above-presented direct R&D financing, innovative companies can benefit from multiple public and private funding streams. PARP distributes seed funding for ICT start-ups through the support measure 8.1 of POIG. There are numerous seed funds and venture capital funds, and innovative companies can also benefit from the dedicated stock market New Connect, which attracts both Polish and foreign listings. Based on the EU Structural Funds, the government indirectly supports the innovative ventures by stimulating the growth of VC funds, business angels and specialized investment funds. Recently established sovereign fund Polish Investments for Development (PIR) initiated its investments in 2014, targeting large infrastructure and technology projects.

The Ministry of Economy 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 August 2013, strengthening the programme's focus on new R&D investments. The recent beneficiaries included: Cisco Systems, IBM and Fujitsu, 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.

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 is also a dedicated funding scheme for research infrastructure, with competitions organised by MNiSW.

Assessment

The Polish R&D performers benefit from the wide availability of funding, in particular distributed through competitive calls for proposals. The nation-wide institutional assessments stimulated internal changes at PHEIs and PROs, highlighting the importance of research excellence and science-industry collaboration. The increase in public funding for R&D triggered disproportional growth of private sector investments in innovations. 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. In 2013-2014, NCBiR dramatically shortened the proposal evaluation cycles, in a move much appreciated by business enterprises.

The primary challenge, related to the R&D funding system, consists in a large number of partially overlapping support measures, which might seem confusing to some applicants. This results however from a gradual transformation of previously available instruments, and introduction of some programmes as pilot measures, which were offered to verify their suitability for new financial perspective. The current portfolio of NCBiR programmes, in combination with plans included in the Operational Programme Smart Growth (POIR) for 2014-2020, will create a more coherent system, with instruments clearly targeting different stages of the innovation cycle or selected research and technology areas.

Another challenge refers to differences in approaches to beneficiaries by various funding agencies. NCBiR is currently perceived as a "fast mover", reacting to results of programme evaluations and specific suggestions for improvements, and maintaining open communication to solve problems arising at the application submission and project implementation stages, while other institutions might represent more traditional, bureaucratic orientation.

Funding beneficiaries experience also negative consequences of legal interpretations, issued by the Ministry of Infrastructure and Development (MIR) with regards to certain support measures from the EU Structural Funds, 2007-2013. A particularly problematic example is large investments in RI, funded from the Operational Programme Infrastructure and Environment (POIŚ). MIR officially classifies them as investments in educational infrastructure, insisting that they could not be used for research, technology development or science-industry co-operation. This interpretation affects a large number of PHEIs and involves substantial shares of public funding. The POIŚ support measure was used to finance purchases of some of the most complex and innovative research infrastructures in Poland, which might remain unused if the MIR's interpretation is not changed to encourage R&D efforts, but at the same time, the change seems unlikely.

Another issue related to the existing R&D funding system involves the insufficient availability of revolving instruments, greatly outnumbered by grants and thus inappropriately conditioning business enterprises, which expect the government to cover most of their risks in innovative projects. This tendency will gradually change in accordance with the recommendations of the Enterprise Development Programme (PRP) and the planned support measures in POIR, 2014-2020. Finally, the lack of tax incentives for R&D performers has already been characterised as a major deficiency of the Polish system in several sub-chapters of this report and will further be addressed in the section below.

2.5.3 R&I funding

The activities of NCBiR in recent years focus 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 large-scale expansion of innovative projects, 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 will be replicated in the future distribution of the EU Structural Funds through POIR, with 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.

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, GDDKiA, INNOLOT, INNOMED, and will also be used for sectoral programmes in the future.

R&I funding is mostly distributed through subsidies, and fiscal instruments such as tax incentives are not popular – in 2013, only 74 companies resorted to tax exemptions related to the implementation of new technologies (MF, 2014: 17). Unfortunately, the existing tax exemptions support the acquisition of technologies or related services, and might 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. Tax benefits are also available to formally approved R&D centres, but as of February 2015, the list only included 34 companies[8] .The inconsistency of Polish approach to tax incentives for R&D has already been described in sub-chapters 2.3 and 2.4.

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 previously-described tax exemptions since 2008 support acquisitions of innovative technologies and know-how, thus stimulating the use of externally developed innovations. The government agency PARP assumed a leading role in

[8] http://bip.mg.gov.pl/O+ministerstwie/Jednostki+organizacyjne+nadzorowane+lub+podlegle/Centra+badawczo+rozwojowe, access date: February 2015

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.

Funding for innovations will be continued in the new financial perspective of 2014-2020, as the Operational Programme "Smart Growth" (POIR) includes selected measures supporting innovations, which were evaluated as the most successful instruments in previous years. Innovation support will increasingly rely on revolving instruments as opposed to subsidies. PARP will probably be the agency in charge of non-R&D innovation support in the coming years, while NCBiR will focus on R&D support. The support includes also measures dedicated to clusters, technology parks and innovation incubators. In POIR, both R&D and innovation activities have adequate, substantial funding allocated, but the focus in 2014-2020 will shift towards R&D as the main target identified in the national RDI policy, supporting the transition from diffusion of innovations towards the endogenous development of new technical solutions. In addition, Regional Operational Programmes for all 16 regions of Poland include measures, related to innovation support in business enterprises, often offered as revolving financial instruments.

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). Beneficiaries of the European Commission's programmes, including FP7, CIP, Horizon 2020, COSME and LIFE+, can also apply for government co-funding, which reduces the financial burden of applicants.

2.6 Smart Specialisation (RIS3)

The Polish government identified prioritized technological and scientific areas, presented as National Smart Specialisation (KIS), as the outcome of multiple-year intellectual exercise, combining industrial and scientific perspectives. KIS was based on cross-analyses of the outcomes of two complementary foresight exercises: MG-coordinated "*Technological Foresight of Industry – Insight 2030*" (2010-2012, 99 technologies identified as key for the growth and competitiveness of the Polish industry) and MNiSW-led "*National Foresight Programme Poland 2020*" (2006-2009, concluded with 680 detailed R&D themes, turned into National Research Programme, KPB, listing 7 strategic R&D directions). The extensive lists of technologies and research areas were compressed into more general groupings, while additional economic and bibliometric indicators helped select the specialities having the highest economic impact, further verified by stakeholder dialogue. KIS consists of 18 identified national specialisations, but the list will evolve based on annual reviews and updates. The national specialisations are not regarded as superior to or linked to the regionally identified specialisations. KIS was adopted in 2014 as an annex to another

policy document PRP and guides the implementation of support measures for business enterprises and scientific organisations, including POIR and PMDIB. KIS did not include specific considerations of financial requirements, as the list of smart specializations was intended to be used in conjunction with relevant implementing documents such as PRP, POIR and PMDIB, but within the broader policy framework, the specialisations were identified with the primary objective of targeting and prioritizing public R&D investments. KIS will be directly translated into project eligibility criteria in R&D support measures included in POIR. POIR states that support will include projects from all thematic areas, but at least 98% of R&D funding for business enterprises will be allocated for projects consistent with the identified smart specialisations (MIR, 2015: 24).

Another limitation of the Polish S3 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.

Facing the above-presented limitations, NCBiR started 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, 40% of budget covered by the aviation industry association; INNOMED for innovative medicine, 35% of budget covered by the Polish Technological Platform of Innovative Medicine), and NCBiR established an ongoing call for submissions allowing interested business associations 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.

Substantial progress has also been achieved with RIS3, due to the planning efforts for the new operational programmes 2014-2020. Poland is divided into 16 regions (voivodeships), and each region has its own Regional Operational Programme (RPO), guiding the distribution of the EU Structural Funds. The ROPs include policy measures, related to R+I, in some cases overlapping with the corresponding measures, available on the national level. List of ROPs and relevant statistics are available at the dedicated government website[9].

[9] http://www.funduszeeuropejskie.2007-2013.gov.pl/Strony/glowna.aspx, access date: February 2015

Several years ago, all 16 regions prepared and formally adopted Regional Innovation Strategies.

These documents were updated in line with the RIS3 framework, reflecting the smart specialization of regions. Since the preparation of RIS3 is the condition for accepting the RPOs, the process was concluded in 2014. Regional authorities were arranging multiple knowledge transfer events, learning from best practices and sharing experiences related to RIS3, and experts from the European Commission and MNiSW were regularly involved in these efforts. Some of the existing RIS3 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, and while the evaluation report criticized the approaches of many regions, the World Bank delivered subsequent contracted services supporting the improvements of regional documents. RIS3 are directly linked to ROPs and focus on stimulating private co-funding for projects, while benefiting from the monitoring and evaluation frameworks of RPOs. The identified specialisations are expected to be regularly monitored and updated if needed, but regional approaches are diversified and definite scope of activities will be confirmed when the regional documents are formally accepted by the European Commission.

2.7 Evaluations, consultations, foresight exercises

Formal evaluations accompany many public RDI 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 in 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 available online[10]. Most of these projects were carried out by external consulting firms to assure the transparency and the reliability of findings. 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 RDI. 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 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. Numerous detailed evaluations of the Operational Programme Innovative Economy (POIG) included: consistency between POIG

[10] 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: February 2015

interventions and the EU horizontal policies (Agrotec, 2011), coherence of POIG with government policy documents (PSDB, 2010), complementarity of POIG interventions with other EU-funded programmes (PSDB, 2011), evaluation of funding priorities 3, 4, 5 and 6 of POIG (PAG Uniconsult, 2011), and evaluation of complementarities and effectiveness of support for entrepreneurs (PAG Uniconsult, 2012). Findings from these projects were used when drafting the new programmes, and removal of certain bureaucratic obstacles in funding agencies.

In 2013, 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. 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, including: evaluation of project selection modes (CRSG, 2013) and evaluation of financial engineering instruments (PAG Uniconsult, Taylor Economics, 2013). An important finding from the latter study concerned the positive expected effect of public interventions for 2013-2020. They would not crowd out private funding as they they address areas of limited interest for private capital (PAG Uniconsult, Taylor Economics, 2013: 7). The Ministry of Infrastructure and Development contracted the World Bank to evaluate smart specialisation strategies, prepared by regions. The social processes leading to the development, evaluation and improvement of POIR involved multiple stakeholders and initiated a broad public dialogue, concerning the need to modernize the economy and focus on the development of innovations. The needs to increase Polish expenditures on R&D, raise the innovativeness of the private sector and stimulate the science-industry cooperation became important theme of popular press publications and political speeches. This was an important change, as the RDI-related topics were not considered important in previous years, when the economy was booming thanks to the low labour costs and large infrastructure investments. The increased awareness is likely to facilitate the absorption of innovation-related funds through POIR, and has already been given prominence by the largest consulting firms and think tanks.

Lists of policy and programme evaluations with links to reports are maintained on a centralised government website[11]. Between January 2013 and August 2014, among 105 evaluation projects 13 directly addressed the innovativeness of the economy, including national or regional levels.

MNiSW also resorted to evaluative techniques to draw conclusions from multiple science and technology foresight studies, conducted by specific regions and industries. The Ministry of Economy worked with the World Bank to evaluate the proposed reshuffling of the enterprise support system and received insights from external experts, outlining the existing barriers related to the "culture of risk aversion", "overly legalistic approach to programme management" and lack of necessary industry exposure and specialist knowledge in government implementation agencies (Kapil et al., 2012: 39), as well as disadvantages of selection procedures excessively relying on "paper-based" applications without direct contacts with applicants, which were supposed to prevent corruption, but established a system, in which the funding for R&D was not allocated to the best applications, but to the applicants, who managed to comply with all of the detailed requirements, often resorting to the help of specialist consulting companies (Kapil et al.,

[11] www.ewaluacja.gov.pl/WYNIKI/Strony/Wyniki_badan.aspx, access date: February 2015

2012: 40). These findings were directly translated into the designs of the Enterprise Development Programme (PRP) and the Operational Programme Smart Growth (POIR). The Supreme Audit Office (NIK) published in 2013 results of a comprehensive audit concerning the commercialisation of research results at PHEIs and PROs, which revealed the insufficient scale of these efforts and procedural problems, faced by scientific organisations when trying to transfer the academically developed technologies to the industry (NIK, 2013). Amendments to The Act on Higher Education from 2014 were direct reactions to the findings of this audit. Polish Patent Office conducted in 2013 an extensive study related to IPR protection by SMEs with the intention to improve the effectiveness and efficiency of the patenting procedures and raise the numbers of patent applications by business enterprises.

In 2013, NCBiR was named "the Innovator of the Year" by Warsaw Business Journal. The award is presented annually by the largest English-language economic newspaper in Poland. The distinction for NCBiR recognizes its effectiveness in stimulating industry-science collaboration, experimenting with new funding programmes and maintaining close relations with the business community. The Centre demonstrated the ability for organisational learning, by streamlining its internal processes in response to the demands of business enterprises and speed up the processing of project applications so that funding decisions in 2013-2014 were made within 60 days only. NCBiR works also with the World Bank on a complex evaluation of its funding programmes, looking for possible improvements before the new EU financial perspective starts.

The Main Statistical Office (GUS) implemented an online system - STRATEG, presenting output indicators used to evaluate public policies, including in the area of RDI.

RDI policies are also inspired by international benchmarking, with particularly close contacts to experts from Israel, as Poland attempts to replicate some of the proven Israeli RDI support instruments, involving public-private partnerships and the involvement of venture capital.

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[12]), and compulsory regulatory impact analyses. Stakeholder consultations were conducted among others for PRP, KIS, POIR and all RPOs. Impact analyses should include the compulsory ex-ante screening of regulations, impacting on entrepreneurship and innovativeness, performed by PARP, in accordance with detailed rules elaborated by the Ministry of Economy (MG, 2006), but PARP has not been preparing such written assessments in recent years. Ex-ante screening and impact analyses are standardized and in some cases, they might be perceived as unnecessary burdens by government officials, who cease to carry out real, in-depth analyses. For example, the recent amendments to The Act on Higher Education were not accompanied by satisfactory projections of expected impacts on the innovativeness of PHEIs and business enterprises.

Two large foresight programmes were conducted several years ago - foresight of science and technology, coordinated by MNiSW, and technological foresight of industry "Insight 2030", managed by MG. Results of both programmes were used in 2013-2014 to identify national smart specialisations (KIS), and both ministries work on updates to and implementations of the foresights.

[12] http://konsultacje.mg.gov.pl, access date: February 201

Polish 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 includes specific RDI-related variables. NCBiR jointly with the consulting company PwC analysed financial data of all RDI projects co-funded by NCBiR, identifying factors which could increase BERD through public interventions (PwC, 2014).

3. National progress towards realisation of ERA[13]

3.1 ERA priority 2: Optimal transnational co-operation and competition

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, 3.1% of GBAORD, with the highest transnational R&D budget among all new EU members states (Eurostat, 2014). 16.1% of this 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, 2014). The situation in 2013 differed 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. Funding agencies NCN and NCBiR stimulate the cooperation by means of information campaigns, co-funding and specialist support. Especially NCBiR is active in launching new co-funding streams. Support measures planned for years 2014-2020 (POIR) prioritize Polish involvement in trans-national initiatives.

"National Research Programme" from 2011 (KPB) set guidelines for applied R&D programmes, and corresponded to the grand challenges at the European level. KPB is reflected in the strategic R&D programme portfolio of NCBiR, and NCN also used it to indicate priority areas for fundamental research (based on the Resolution of the Council of NCN). The list of National Smart Specialisations from 2014 (KIS), which will impact the distribution of the EU Structural Funds for 2014-2020, also directly corresponds to these grand challenges.

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 also maintains bilateral cooperation programmes with Norway, Czech Republic, Israel, Luxemburg, Germany, Singapore and Taiwan (with co-funding managed by NCBiR). Jointly with Czech Republic, Hungary and Slovakia, it maintains the Visegrad Fund, which supports among others co-operative R&D projects involving researchers from the four countries.

[13] Contents of chapter 3 are partially based on the ERA Communication Fiche 2013 for Poland (Klincewicz, 2013)

The government maintains a central, national contact point for EU programmes (KPK) and network of regional contact points, supporting applicants to programmes such as Horizon 2020 by information sharing and free advice. EU programme LIFE+ is supported in Poland by the National Fund for Environmental Protection and Water Management (NFOŚiGW), and 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. In 2014, MNiSW published "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.

Polish researchers benefit 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").

The Act on the Principles of Financing Science (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.

The Act on Higher Education (including amendments from 2011) facilitated research cooperation of universities by setting general guidelines related to the protection of academic IPRs and requiring the universities to define relevant bylaws. Accordingly, the Act on National Research & Development Centre (NCBiR) (2010) assigned the ownership of IPRs for inventions created in projects co-funded by NCBiR to organizations, which benefit from the public funding, unless the assignment is regulated in different ways in a specific funding agreement.

The draft Operational Programme "Smart Growth" (POIR), defining the rules for distribution of the EU Structural Funds in years 2014-2020, includes measures, supporting the internationalization of Polish science through support for the creation of international research agendas, helping enterprises and scientific organizations in preparation to participate in international programmes, stimulating cross-border R&D by enterprises and

research organizations and co-funding Polish research teams participating in international R&D programmes. Certain R&D support measures included in POIR will be complementary to Horizon 2020 funding, with plans to use criteria/evaluation results of H2020. Nevertheless, as of 2014, no common ex-post evaluation procedures have been implemented.

3.2 ERA priority 3: An open labour market for researchers. Facilitating mobility, supporting training and ensuring attractive careers

3.2.1 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 planned for 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 2011 for 0.48% of the labour force (EU-27: 1.07%) (Eurostat, 2013). 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) is relatively low at 4.4% in 2012 (similar to EU-27), but has gradually been increasing since 2008, when it was only 2.7% (Eurostat, 2013). 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).

3.2.2 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 (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 - 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. 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.

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.

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 outcomes of the implementation of the legal framework, established in 2010-2011, have not yet been formally evaluated. One can however notice that 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.

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. Regular evaluations of academic performance of individual researchers, linked to the temporary character of their employment contracts, tend to be criticized by older generation of researchers, who were accustomed to tenure-type of contracts. An important element of the Polish innovation system is the broad availability of specialist trainings for researchers, including free of charge programmes, co-funded from the EU Structural Funds.

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.

3.2.3 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 the Principles of Financing Science (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.

3.2.4 EURAXESS

The Act on Higher Education (including amendments from 2011) stipulates that all job offers at the public higher education institutes need to be published online on websites of the university, the Ministry of Science and Higher Education and "*websites maintained by European Commission - European portal for mobile researchers, dedicated for the publication of job offers for researchers*". Similar regulations were incorporated into the Act on the Polish Academy of Sciences (2010) and the Act on Research Institutes (2010). Poland participates in the EU Scientific Visa package.

The previously mentioned amendments to the Act on Scientific Degrees and Scientific Title and Titles in the Area of Arts (2011) facilitated the award of the title of professor to researchers with good careers records within foreign research systems without the need to satisfy the formal requirement of holding a Polish post-doctoral degree (habilitation). The Ordinance of the Minister of Science and Higher Education concerning recognition of foreign scientific degrees, and titles in the area of arts (2011) defined modalities for recognizing foreign academic degrees (Ph.D., habilitation, professor), and simplified procedures for degrees awarded by countries-members of the Lisbon Recognition Convention.

EURAXESS Poland operates since 2009, with English-language online services, information portal, regular publication of job offers in Poland and calls for proposals for grants, scholarships and fellowships in Poland. EURAXESS maintains a decentralized regional structure with 10 EURAXESS Service Centres in 10 different academic cities in Poland.

EURAXESS focuses on standardized information services, with online publications available to all interested researchers (including "Foreign Researchers' Guide to Poland", updates on R&D funding and job openings), but their tailor-made services to individual researchers are more limited.

3.2.5 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 will support the launch and delivery of innovative doctoral studies, with

preference for interdisciplinary programmes, involving international researchers and science-industry collaboration.

3.2.6 HR strategy for researchers incorporating the Charter and Code

The principles of the Charter and Code were only partially transposed in the national laws and policy initiatives. The Act on Higher Education (including amendments from 2011) introduced numerous regulations, which are consistent with the Charter & Code, strengthening the HR policies of higher education institutions and empowering their employees. Researchers working for public research institutes benefit from corresponding regulations, defined by the Act on the Polish Academy of Sciences (2010) and the Act on Research Institutes (2010). Career tracks in scientific organizations are defined by hard laws, with precisely defined criteria for promotion and award of scientific degrees and titles. Employment terms and conditions are defined by law and organizational bylaws, which are set in cooperation with labour unions. National laws, fellowships and research grant frameworks implement the principles of merit-based support for skilled researchers. Ethical aspects of research efforts, outlines by the Charter & Code, were transposed by the "Code of a researcher's ethics", prepared in 2012 by the Polish Academy of Sciences and actively promoted by the government.

Declarations of endorsement of the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers were issued among others by the Conference of Rectors of Academic Schools in Poland (KRASP), the Polish Academy of Sciences and the Foundation for Polish Science (FNP). As of 2014, 13 institutions have formally signed up for the process, and 4 received the logo. Even though the endorsement for the contents of the Charter & Code and acceptance for general directions related to the HR Strategy for Researchers are wide-spread in Poland, organizations do not define own, formal HR strategies, carry out self-assessments or prepare action plans. Government authorities do not incentivize the effective implementation of HRS4R, neither do actively promote the Charter and Code in Poland.

The academic labour market in Poland became more attractive in recent years, particularly for young researchers, due to the availability of competitive R&D funding and significant improvements in recruitment and career regulations. 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. Foreign researchers find the Polish job market less appealing due to language barriers (in particular, jobs at PHEIs tend to involve teaching in Polish language) and salaries lower than in Western European countries, but this is gradually changing, in particular due to the availability of modern research infrastructures.

3.2.7 Education and training systems

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. The reform introduced also obligatory IPR management classes for all university students. 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, 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.

It is worth noting that in the National Reform Programme 2013, the government referred to the necessary "*upskilling of Polish R&D sector staff, including also the employees of companies carrying out activities in the field of R&D*" (RM, 2013b: 20).

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). The new Operational Programme POWER will support the establishment of a "national qualification system", supporting the comparability of employee qualifications, as well as the building of a unified "*register of [HR] development services*", intended to stimulate life-long learning. POWER includes also measures supporting the delivery of studies prepared jointly with employers, international study programmes, and instruments supporting the excellence in education on various levels, including higher education and development of managerial competences of PHEI employees (MIR, 2014).

3.3 ERA priority 5: Optimal circulation and access to scientific knowledge

3.3.1 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 or logins, facilitating access to multiple electronic resources. 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.

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.

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.

3.3.2 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 only publish 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 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: 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 (Polish counterpart of commercial bibliographic databases such as Web of Science and Scopus, offering basic access to data free of charge as well as paid options, maintained by a stock-exchange listed company IDH S.A.). 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.

In 2012, Ministry of Administration and Digitization published draft guidelines of the Act on Open Public Resources, which faced fierce criticism of researchers and legal experts. Contents generated by government institutions (including public R&D organizations) were supposed to be available through open access, in particular: scientific journals financed from the science budget, scientific publications from publicly funded projects. In 2014, the Ministry made a renewed attempt to regulate the access to public resources, by initiating consultations of new guidelines, which excluded scientific organisations from the upcoming legal act (i.e. the Act will not have any implications for the open access to research data or publications, and will only concern data collected by public administration).

4. Innovation Union

4.1 Framework conditions

The RDI policy framework, established in recent years, considers business investment in research and innovation as a prioritized area. Policy documents SIEG, PRP and POIR, as well as legislative efforts, have clearly articulated the needs to improve the enabling environment for innovations. The importance of framework conditions was also highlighted by an extensive evaluation of the Polish RDI system, prepared by the World Bank (Kapil et al., 2012). The implementation of support measures for the 2014-2020 perspective is accompanied by ongoing organisational efforts to reduce administrative burdens, eliminate excessive bureaucracy. In 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 worldwide (World Bank, 2014).

There is strong focus on supply-side policies and instruments, offering public co-funding and stimulating private funding for RDI, 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 NCBiR, PARP and KFK offer instruments targeting 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, but the government launched efforts to implement dedicated, R&D-related tax exemptions.

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.

4.2 Science-based entrepreneurship

Multiple dedicated measures facilitate the creation of university spin-offs and the related knowledge transfer. Commercialisation of research results became one of core themes of science and higher education reform from 2010-2011, and subsequently new funding schemes were launched.

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. PHEIs and PROs are subject to stringent public finance and public procurement regulations, and these companies benefit from relaxed legal requirements, similarly to other commercial entities. 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 receive not only 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.

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 Alpha (seed funding for scientific spin-offs) and BRIDge VC (VC funding for larger and more mature, science-based ventures).

FNP SKILLS programme encompasses training in technology transfer ("SKILLS – Szkolenia"), coaching ("SKILLS – Coaching"), and funding competition for the most promising commercial ideas ("SKILLS – IMPULS").

MNiSW, NCBiR and 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 addition, science and technology parks and technology incubators were supported by POIG 5.3 measure, and corresponding measures are planned in the 2014-2020 financial perspective (POIR). 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.

Young, innovative companies can benefit from standard RDI schemes, helping them commercialize their ideas, e.g. NCBiR's DEMONSTRATOR+ (supporting the development of technology prototypes, ready for commercialization) and NCBiR's INNOTECH (technology development). A detailed list of available programmes was presented in chapter 2, and science-based SMEs are eligible for most of these initiatives. 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. Additional support measures are available for SMEs from specific sectors, e.g. ICT (POIG 8.1) and environmental technologies (Green Technology Accelerator GreenEvo by Ministry of Environment). Ministry of Foreign Affairs through its embassy network organizes regular match-making meetings with potential partners, offering networking support for science-based companies, and Ministry of Economy with PAIZ and PARP offer regular match-making events for selected geographical destinations (including the programme "Tech-Match Poland", establishing contacts between Polish innovative firms and partners from the Silicon Valley).

4.3 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. 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. In 2013, the Polish Patent Office carried out an extensive evaluation of its patenting procedures and an opinion survey of SMEs, attempting to improve the internal organisation and raise the numbers of patent applications by business enterprises. 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; POIG 5.4.1 support measure of PARP; eligibility of expenditures on IPR protection in most of applied R&D funding streams; a relevant planned measures in POIR for 2014-2020). 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.

No transnationally co-ordinated IPR policies exist in Poland. 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).

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. There are no publicly sponsored IP trading platforms, and no investment funds directly focused on investing in IP.

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 upcoming financial perspective 2014-2020 (POIR), public co-funding related to IPR will extend beyond mere patenting, covering also relevant consulting services, facilitating commercialisation and IP-based transactions.

4.4 Knowledge transfer and open innovation

The R&D partnerships between private and public organizations were actively promoted during the science and higher education reform from 2010-2011, and the RDI policy documents in Poland assign high priority to the science-industry co-operation. Specific data on researchers at PHEIs and PROs, having work experience in the private sector, are not collected on a national level. 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). There are numerous R&D partnerships and joint collaborative research agendas involving the public and private sector, in many cases motivated by the availability of public funding. Out of 10,654 holders of the professor title, 73 work as R&D personnel in business enterprises (0.68%) (GUS, 2014b). Data on invention disclosures at academic institutions are not available, but in 2013, altogether 1,703 patent applications were filed with the Polish Patent Office by scientific institutions. Out of 4,237 patent applications in 2013,

26.46% came from HEIs, 11.10% from PROs and 2.64% from the Polish Academy of Sciences (UPRP, 2014: 12-13).

In a survey of large and medium-size business enterprises, carried out by the consulting company KPMG, 52% of respondents ranked the effectiveness of R&D projects contracted to HEIs or PROs as very high, and further 5% expressed positive evaluations of this type of co-operation (KPMG, 2013: 18). 32% of surveyed companies planned to commission R&D projects from scientific organisations (KPMG, 2013: 35). The data stand in a stark contrast to results of earlier studies, conducted before the 2010-2011 reform, when respondents tended to emphasize the underlying divergences, inhibiting effective science-industry co-operation. This co-operations is nowadays considered an imperative, strongly promoted by the government and mass media, and embraced by many scientific institutions.

The Strategy for Innovation and Efficiency of the Economy for the years 2012-2020 (SIEG) and the Enterprise Development Programme (PRP) stress the importance of knowledge transfer and co-operation between scientific institutions and industry. The Operational Programme Smart Growth (POIR), which will guide the distribution of the EU Structural Funds in years 2014-2020, introduces multiple funding instruments, intended to stimulate the cooperation between business, HEIs and PROs. It includes explicit requirements to form business-science consortia. Specific funds will also be dedicated to launch awareness campaigns, promotion and training, focused on further supporting the cooperation between business enterprises and scientific institutions. Public funding modalities for applied R&D motivate scientists to search for business partners, and encourage companies to liaise with public research organizations or higher education institutions. Particularly beneficial are multiple grant programmes by NCBiR. Since 2011, universities started forming dedicated technology transfer companies and spin-offs thanks to the clear legal mandate from the legislator. 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. No data on the number of academic spin-offs are available, and the Polish landscape is confusing due to the existence of companies, established by academics but not affiliated with PHEIs or PROs.

The measures, supporting R&D co-operation projects between public/academic/not-for-profit research institutions and business enterprises include:

- 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 works 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, who influence the thematic calls for proposals - INNOLOT, INNOMED, CuBR, RID, all offered by NCBiR;
- R&D programmes targeting scientific institutions, in which having a business partner positively influences the proposal evaluation - NCBiR's LIDER, BRIDGE;

- PARP's "innovation voucher" programme, funding R&D projects contracted to PHEIs and PROs by business enterprises.

The above-listed support measures are regularly evaluated, and in 2012-2013, the Supreme Audit Chamber carried out a large-scale analysis of the science-industry knowledge transfer activities (NIK, 2013). The latter report motivated the government to further modify some support measures, and amend the Act on Higher Education in 2014 to facilitate the commercialisation of research results by allowing scientists to own IPRs to their academic inventions. During social consultations of major policy documents and legal acts, the effectiveness of relevant KT frameworks and support measures was thoroughly discussed, with dedicated evaluative studies commissioned by the government[14], and the topic raised interests of think tanks and consulting companies (comp. e.g. KPMG, 2013).

The upcoming financial perspective of 2014-2020 triggers a major change in approaches, as the previous funding programme based on the EU Structural Funds, POIG (2007-2013), had separate support measures for scientific institutions and private sector organisations, thus deepening the inter-sectoral differences, while the new programme POIR (2014-2020) integrates the sectors, promoting their co-operation or even making it a compulsory requirement in the case of some support instruments.

Poland offers multiple measures, intended to support cooperation and knowledge transfer between the public and private sector. Dedicated programmes by NCBiR, promoting business-academia linkages, include: "BRIdge VC" (support for innovative technology ventures from public sources with co-funding from VC funds, including foreign VCs), "Creator of innovativeness" (support for technology transfer efforts and creation of enabling environments), and "SPIN-TECH" (support for the launch of special-purpose companies, established by universities to commercialize research results). The Ministry of Science and Higher Education manages the programme "Top 500 Innovators Science - Management – Commercialization", which involves 9-weeks training sessions for young researchers and employees of technology transfer centres of PHEIs, helping them acquire competences that support commercialization of research results. Another MNiSW programme – "Innovation Brokers" - relies on an innovative use of public funds to cover costs of hiring technology brokers by public universities in order to help them commercialize selected research results. Part of the funding is conditional on the outcomes of commercialization processes, thus additionally increasing the motivation of brokers to close the sales or licensing deals. 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. 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. Consulting services related to development and implementation of innovations are offered to small and medium-size business enterprises by a network of KSU based on funding from POIG[15], and science-industry collaboration is also stimulated by means of "innovation vouchers", distributed among companies and used to co-fund R&D projects carried out by scientific organisations.

[14] Comp. database of evaluation projects available at: www.ewaluacja.gov.pl/WYNIKI/Strony/Wyniki_badan.aspx, access date: February 2015.
[15] http://ksu.parp.gov.pl/pl/oferta_ksu/innowacyjnosc-w-przedsiebiorstwie, access date: February 2015.

Framework conditions, incentivising and rewarding academics engaged in cooperation with industry/users, are linked to the legal framework in Poland. Public-private partnerships in R&D were enabled by the possibility of commercializing publicly funded research-results, encouragements to establish academic spin-offs, and a regular measurement of performance in commercial knowledge transfer (including licensing and sale of IPRs) as part of institutional assessments of R&D organizations. The Act on the Principles of Financing Science (2010) offered funding for joint initiatives between scientific organizations and business enterprises, especially for the formation of research consortia. The Act on Higher Education (including amendments from 2011) encouraged public higher education institutes to co-operate with business enterprises and obliged universities to form special purpose companies, dealing with technology transfer, and to define IPR management rules. Universities were also expected to co-operate with external stakeholders, including business, when defining programmes of study. Accordingly, the Act on Research Institutes (2010) obliged them to co-operate with business enterprises, sell products, services and technologies, and form R&D consortia. The Act on the National Research & Development Centre (NCBiR) (2010) facilitated access to public funds for applied R&D granted to business enterprises, also based on consortium agreements with scientific organizations, and confirmed that IPRs to publicly funded inventions rest with the creators.

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. 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.

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. FNP offers an alternative approach with its set of programmes called SKILLS, covering sponsored internships of researchers at business enterprises or foreign research institutes, training sessions related to commercialisation of research results, and competitions for innovative R&D projects by researchers, doctoral students, and recent PhDs who are not yet employed (SKILLS-IMPULS programme).

In July 2014, the Parliament amended the Act on Higher Education and the Act on Polish Academy of Sciences, introducing a major novel regulation. 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 PROs, further differentiating the public scientific institutions. The same amendment of 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.

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. There are no dedicated measures, which would specifically support open innovation in the context of optimizing the circulation of knowledge between academia and the private sector, or within the private sector. The declaration of policy support for open innovations is included in SIEG and PRP, but existing support measures favour knowledge transfer on commercial terms, through proprietary agreements.

Most Polish regions included in their Regional Operational Programmes 2007-2013 measures targeting knowledge transfer, with project budgets smaller than in the case of projects supported by central agencies. They were usually offering grants for R&D projects, with the possibility of science-industry co-operation. In some regions, projects supporting internships of scientists in business enterprises were launched (comp. the previously introduced example of "TEKLA+"). Similar measures are planned for the upcoming financial perspective 2014-2020, but the future support will be restricted to areas identified as regional smart specialisations.

4.5 Innovation framework for SMEs

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.

Public policies actively promote a favourable environment for SMEs, and many relevant instruments have already been presented in the sub-chapter 4.4. Multiple, previously described RDI support measures are intended to stimulate the formation of partnerships with the involvement of SMEs.

Public co-funding is also available for innovation clusters. An interactive online Cluster Map references 143 clusters as of 2014. 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 mostly be offered to "key clusters", identified in a nation-wide competition, to maximize the effectiveness of support. NCBiR offers "sectoral programmes", supporting R&D initiatives defined jointly with a representation of an industry sector (cluster organisations or business associations).

SMEs can also 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, European Investment Bank started offering credit guarantees for innovative SMEs in Poland, through their partner bank Pekao S.A. Most 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. The tendency to distribute applied R&D funding primarily to companies will be further strengthened in POIR, for the 2014-2020 period.

There are multiple support schemes to finance innovation, particularly in the context of SMEs. In the financial perspective of 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. However, Polish regions will also have their own support measures in regional operational programmes and some of them might overlap with the nation-wide instruments. Recent improvements concern also the reduction of excessive bureaucratism in project funding procedures. This problem was identified by World Bank in its evaluation of the Polish RDI 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). Most funding schemes are regularly evaluated, but there are no formal benchmarking exercises against comparable schemes in other countries.

No new partnerships were established between government agencies and the European Commission on EU R&I programmes for SMEs, but Polish applicants can benefit from domestic co-financing and specialist support, offered by the funding agencies. Funds are earmarked for participation of Polish research teams and SMEs in internationally coordinated R&I initiatives, and distributed based on regular, open competitions.

4.6 Venture capital markets

Public co-funding, distributed by KFK (National Capital Fund) contributed to the establishment of 16 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 16 funds in 2014 amounted to €247m. The funds were carefully selecting investment targets, maintaining focus on specific types of technologies, sector and growth stages, with only 26

transactions completed as of 2014 (mostly in ICT area). 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 POIR, 2014-2020, taking into account results of evaluations of the past support measures and public consultations with the investing community.

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 Alpha 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. The innovative financial instrument proved also challenging from the perspective of public aid regulations, and the elaboration of a tailored legal framework for the programme was necessary. NCBiR informed also in November 2014 about the plans to launch a joint technology investment fund with the largest Polish insurance company PZU, and the fund is expected to operate in a manner similar to other BRIDge initiatives.

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.

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 investments through fiscal measures. The largest and most capital intensive projects, having potentially significant impact on the innovativeness of the economy, can be funded by the sovereign investment fund PIR (*Polskie Inwestycje Rozwojowe*, Polish Investments for Development), but PIR so far focused rather on large infrastructure projects. Industrial Development Agency (ARP) announced in November 2014 plans to establish its own VC arm, but the operationalization of its new strategy will start in 2015. 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 invested in 2013 in an innovative start-up *NanoCarbon*, established by scientists who developed and commercialized a method of manufacturing graphene.

Despite the wide availability of public co-funding for VCs, business angels and seed investors, no dedicated tax exemptions are 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. NCBiR BRIDge can be expected to offer important, new approach to the VC community, but the support measures have only recently be initiated and thus it is too early to evaluate their effectiveness.

4.7 Innovative public procurement

The use of innovative public procurement is very limited in Poland. Public sector organisations tend to rely on quantitative criteria (mainly price) in tenders. The 2014 amendment to the Act on Public Procurement was intended to encourage a broader use of qualitative criteria, but its actual impact is unclear yet. In recent years, PARP carried out multiple training and publication activities intended to improve the quality of public procurement procedures. Many public sector organisations display conservative attitudes in this respect, resulting from past experiences with invasive oversights of public procurement procedures, and thus are not willing to experiment with new approaches.

No dedicated budgets or targets exist for innovative public procurement. 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. An important, large-scale example contradicting the concept of GPP was the legally mandated public tenders for waste collection and processing systems, happening in every municipality in 2013. The legislation defining the municipal waste collection systems enforced the preferences for the lowest price when selecting the winning bids, thus discouraging environmentally friendly solutions. However, regardless of the official GPP-related activities, public subsidies for the purchases of solar collectors in recent years yielded an impressive increase in the installed solar collector surface compared with other EU member states and strengthened the innovativeness of domestic suppliers, even though this form of support was not officially considered a case of innovative procurement.

When considering the scope of activities related to innovative public procurement in Poland, particular attention should be attached to the so-called “strategic programmes” of NCBiR, initiated in 2010, and concerning several areas considered key for the Polish innovation system, as defined in the National Research Programme (KPB). Calls for proposals in these programmes were very specific, and applicants were obliged to respond to detailed needs expressed by NCBiR, defined in co-operation with other relevant institutions. While the strategic programmes were not positioned as innovative public procurement, their modalities for defining requirements and selecting beneficiaries resemble the idea of innovative public procurement. Strategic programmes included among others: development of a large-scale IT system for scientific sector in Poland, increasing

the energy efficiency of buildings, improving the safety of mining, preparing the diffusion of nuclear energy in Poland, developing advanced energy generation technologies, improving therapies for lifestyle diseases, and increasing biosafety in food production, water management, forestry and agriculture.

Another identified challenge is the reluctance of the Polish public administration towards the use of pre-commercial procurement (PCP), i.e. products and services, which do not yet exist and require intensive R&D efforts upon the selection of suppliers, with the involvement of clients and iterative definition and modification of specific requirements. The reluctance might be linked to the feared legal complications and preferences for the traditional public procurement scenario. At the same time, PCP seems particularly suitable for projects, supposed to address socio-economic challenges, for which no ready-to-use solutions exist. 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 we 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.

Relevant procurement activities 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 (1.95% of GDP per annum target, defined by national legislation). Poland is about to finalize its payments for the acquisition of F-16 fighter planes from 2003, and is expected to redirect a larger part of the defence budget towards orders from domestic R&D performers in the coming years.

Development of IT systems for public sector organisations is also an important source of innovativeness. Large-scale projects are carried out in most parts of the government, and competences resulting from the domestic development of IT systems can afterwards become the basis for successful exports of IT suppliers (as in the case of large IT companies Asseco or Comarch). Regrettably, there are also many examples of IT-related tenders, where the selection of low-cost suppliers resulted in major implementation problems.

The publicly-funded health care also relies on a specific form of innovative procurement, by subsidizing selected medicines to decrease their costs to patients and health care institutions. These activities have important side-effects: they stimulate demand for locally manufactured drugs. In many instances, it led to the development of counterparts of blockbuster drugs, synthesized in alternative ways to avoid IPRs infringements, successfully patented and even exported afterwards (with pharmaceutical companies Adamed and Polpharma being the most active players in this field). A large-scale, multi-annual government initiative "National Cancer Prevention Programme" contributed to the establishment of local radiopharmaceutical companies and laboratories, becoming another example of innovative procurement.

Another important example of innovative procurement is linked to Poland's accession to the European Space Agency in 2013, as the Agency actively uses procurement modalities and first ESA tenders, accessible to the Polish applicants, encouraged the activities of innovative domestic space, defence and IT companies. On the national level, ESA applicants are supported by PARP, which acts as a contact point and provides specialist information to boost the business engagement.

Additional challenges concerned PHEIs and PROs, which are obliged to comply with public procurement regulations whenever contracting services or purchasing inputs to R&D projects. In August 2013, the government proposed and in February 2014, adopted amendments to the Act on public procurement, addressing the specific cases of purchasing services related to scientific, development and research services. The maximum cap for releasing such orders from the public procurement regulations was increased from €14k to €30k. In addition, orders for R&D work, not intended to be directly used for commercial manufacturing purposes, can now be arranged through single source procurement ("*zamówienie z wolnej ręki*"), and procurement results could be nullified if the purchasing organisation fails to secure the needed, external funding for its R&D project. The amendments seem to adequately address the previous concerns of the research community and facilitate the science-industry co-operation.

5. Performance of the National Research and Innovation System

5.1 Performance of the National Research and Innovation system

Poland's R&I system experienced significant changes in the recent years, and key R&D indicators are constantly improving, but most of the indicators summarized in Table 4 remain below the EU average levels, with the notable exception of public funding for innovations (other than R&D support). Polish researchers can benefit from funding for research infrastructures and many large-scale RI projects have recently been completed. There is also a gradual increase in the availability of competitive project funding. These inputs are not yet visibly influencing outputs, as the relative counts of international scientific co-publications represent about 65% of the EU average, the national share of top cited publications is three times lower than for the entire EU, and international patenting in relation to GDP is approximately 1/10 of the EU-28 level. The growth in R&D-related spending indicates that political actions bear their first fruits, but the country needs more intensive efforts in order to effectively transform its RDI system. The transformation is inhibited by the substantial size of the system (number of institutions, researchers, students and projects), and its democratic character, i.e. legal requirements for consultations of draft legislations with the representatives of science sector. "*Innovation Union Scoreboard 2014*" assigns Poland to the group of moderate innovators i.e. countries with innovation performance of 50-90% of the EU average, and the report notes Poland's promotion from a lower-ranked group in 2013 (EC DGEI, 2014: 11). The relative weaknesses concern: non-EU doctorate students, PCT patent applications in societal challenges, as well as license and patent revenues from abroad, while strengths lie in non-R&D innovation funding and education of the youth (EC DGEI, 2014: 63).

In 2012, Poland produced on average 8.46 publications per 10,000 inhabitants, well below the EU-28 average (13.8). They are also significantly less internationally orientated than other EU countries with 28.05% of publications internationally co-published (the lowest value among all EU-28 Member States). In the period of 2002-2012, only 5.26% of the Polish scientific publications were in the top 10% most cited publications worldwide in comparison with 11% of top scientific publications produced in the EU-28 (Science Metrix, 2014)[16]. The share of public-private co-publications in Poland is 1.1% in the period 2008-2013 against 2.8% for the EU-28[17]. The Polish innovation system is regionally diverse, as Masovia (with the capital Warsaw) has substantially higher R&D intensity, and belongs to the 50 most publishing regions of the EU according to the Innovation Union Competitiveness report for 2013 (EC DGRI, 2014: 149-153).

Statistics on applications to national patent office are not always comparable across countries, but they offer insights into technological development activities, which might not be captured by EPO or PCT data. In Poland, approximately 1491 applications were made at

[16] These publication data are based on Elsevier's Scopus database. ScienceMetrix, Analysis and Regular Update of Bibliometric Indicators, study conducted for DG RTD. They represent an update of the data displayed in the table below. See also http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=other-studies

[17] Scival 2014, Scopus based publication indicators derived from Elsevier's SciVal platform, www.scival.com, access date: December 2014

the EPO in the period 2000-2010. Approximately 1749 patent applicants resorted to the PCT route (2000-2010). The Polish Patent Office (UPRP) received over 25 thousand applications in this period (these three figures are based on fractional counting[18]). More recent data, covering the year of 2013, are available in full counting format only. Polish inventors actively patent inventions in the domestic patent office, with 4,237 patent applications (UPRP, 2014: 12) and 2,339 patents granted in 2013 (UPRP, 2014: 19), compared with 510 EPO applications by Polish organisations and individual inventors in 2013 (UPRP, 2014: 27).

Table 4. Assessment of the Performance of the National Research and Innovation System

1. ENABLERS	Year	PL	EU
Human resources			
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	2011	0.50	1.70
Percentage population aged 30-34 having completed tertiary education	2012	39.10	35.80
Open, excellent and attractive research systems			
International scientific co-publications per million population	2012	225.54	343.15
Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	2009	3.81	10.95
Finance and support			
R&D expenditure in the public sector as % of GDP	2012	0.56	0.75
Venture capital (early stage, expansion and replacement) as % of GDP	2012	0.05	0.08
2. FIRM ACTIVITIES			
R&D expenditure in the business sector as % of GDP	2012	0.33	1.31
Linkages and entrepreneurship			
Public-private co-publications per million population	2011	5.33	52.84
Intellectual assets			
PCT patent applications per billion GDP (in PPS€)	2010	0.46	3.92
PCT patent applications in societal challenges per billion GDP (in PPS€) (climate change mitigation; health)	2010	0.06	0.85
3. OUTPUTS			
Economic effects			
Contribution of medium and high-tech product exports to trade balance	2012	0.58	1.27
Knowledge-intensive services exports as % total service exports	2011	28.26	45.26
License and patent revenues from abroad as % of GDP	2012	0.05	0.59

Source: European Commission, IUS Database (2014).

Below, a broad assessment of the performance of the national Research and Innovation system is presented, using the framework defined by the "*Innovation Union self-assessment tool*"[19].

[18] The data are derived from the study: KU Leuven, Bocconi University, "Patents and licensing study", for EC DG RTD – data release: summer 2014

[19] http://ec.europa.eu/research/innovation-union/pdf/innovation-union-communication_en.pdf, access date: February 2015

(1) Importance of the research and innovation policy

R&I policies are embedded in the national policy framework, which is comprehensive, coherent and integrated, with the top-level document National Development Strategy from 2012, SIEG as one of 9 domain strategies (addressing directly innovativeness and competitiveness of the economy), PRP as implementation programme related to business enterprises, and POIR as the framework governing the future distribution of the EU Structural Funds. R&I challenges are addressed on multiple levels, with 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 and R&D activities. There are targeted policy initiatives, addressing major societal challenges by means of R&D and complementary activities, related to the diffusion of relevant innovations. However, the relevant policies had been forged through a complex and difficult process of inter-governmental consultations, with several ministries / government agencies attempting to have stronger influence over the R&I policy setting process, so the current system resulted from a consensus, which does not satisfy some of the agencies and is likely to be revised whenever an opportunity arises, due to government changes. The R&I policy framework has only recently been finalized and since many elements are novel in the Polish context, it will take some time to fully enact the policies, especially as many planned actions are linked to the 2014-2020 financial perspective.

(2) Design and implementation of research and innovation policies

R&I policies are based on a multi-annual strategy with assigned budgets (both from the state budget and the EU Structural Funds). The funding for RDI was not reduced in spite of the economic downturn of the recent years (with only minor adjustment in the middle of 2013), thus ensuring the predictability of funding. Policies have been drafted and improved through broad social consultation process, involving relevant, non-governmental stakeholders. The policies include an integrated, hierarchically structured system of objectives/priorities, the number of priorities is limited to facilitate the implementation of the policies and corresponds to the EU priorities in RDI. The government actively monitors progress by using output indicators, ex-ante and ex-post evaluations. One of deficiencies is the decentralized political structure, as relevant policies are steered by several ministries / government agencies. In the recent years, the rivalry between them supported continuous improvement, but it could also potentially be damaging in the future. Smart specialisation strategies are focused on prioritisation (i.e. selection of specialisations), without differentiating policy interventions for the identified specialisations to further increase their effectiveness, but the new "sectoral programmes" of NCBiR have the potential to overcome this limitation.

(3) Innovation policy

Innovation-related policies promote not only technological innovations, but also innovations in a broader sense (also organisational and marketing innovations, innovations in service sector, eco-innovations). This is demonstrated in particular by activities of PARP, the government agency supporting business enterprises, and NCBiR, the applied R&D funding agency. The stimulation of open innovations is recognized as an important policy direction, both in SIEG, PRP and POIR (with dedicated support instruments and funding). Nevertheless,

supply and demand-side policies in certain sectors are not always consistent (e.g. in renewable energy, information technologies, pharmaceuticals).

(4) Intensity and predictability of the public investment in research and innovation

Public investment in R&D in Poland is relatively high compared to other EU countries in absolute terms and has been increasing in recent years. Significant increases in BERD in 2012 and 2013 demonstrate positive developments in the private sector. The public funding for innovations is predictable due to multi-annual plans and stable science budget, which was strengthened in 2013-2014 by explicitly expressed R&D priorities. Public support instruments were designed to leverage private sector investments, including public-private partnerships in joint sectoral R&D funding programmes. The use of innovative financing solutions was explored by public institutions with reference to R&D, in particular: co-operation with VC funds to finance R&D ventures (NCBiR), sovereign investment fund (PIR), liaising with business angels and investment funds (PARP), supporting VCs targeting mature, innovative companies (KFK) and offering credits for implementation of technological innovations (BGK). While corporate tax exemptions for companies acquiring technological innovations exist, stimulating inbound technology transfer, no comparable tax benefits exist for R&D performers, with unclear plans to introduce them in the future.

(5) Excellence as a key criterion for research and education policy

Science and higher education reform of 2010-2011 put strong emphasis on and incentivised the excellence in R&D, including by competitive project funding and institutional funding linked to the results of R&D evaluations. Public funding for R&D is allocated based on clear rules, defined by legal acts, with rationale for using competitive and institutional funding. Research infrastructure investment are prioritized by means of a national roadmap (PMDIB), with funding planned for 2014-2020, and selection based on transparent procedures with peer-reviews to analyse the importance and excellence of the RI-based research projects and commercialization opportunities. Nation-wide evaluations of scientific institutions are based on research excellence, with transparent rules and use of bibliometric indicators. Funding agencies NCN and NCBiR use external peer-reviews for competitive project funding. Research excellence is regarded as an important criterion to evaluate individual researchers, with legal requirement to conduct regular assessments of a researcher's professional progress at PHEIs and PROs. Open recruitment procedures are pursued by PHEIs and PROs, with job offers published online on MNiSW portal, and selection procedures defined in a formal manner by individual institutions. Employment regulations help reconcile private and professional life at PHEIs and PROs, and share of women researchers is above the EU average

There is however limited portability of research grants across institutions in Poland (funding agreements are signed with specific organisation and cannot easily be transferred), and no cross-border portability of Polish research grants. Moreover, recruitment procedures at PHEIs and PROs have only limited transparency, resulting in the tendency to hire candidates identified before the recruitment started in spite of the appearance of the openness. PHEIs and PROs do not fully benefit from alternative sources of funding such as philanthropy and corporate investments, due to the lack of legal or tax

incentives for the potential donors. Employment conditions at PHEIs and PROs in Poland remain relatively unattractive when compared with many EU countries due to low remuneration of researchers, with maximum salary levels stipulated by law, thus causing regular brain drains of some of the best researchers. No compelling incentives attract leading international scientists to work in Poland.

(6) Education and training systems

Higher education reform of 2010-2011 improved the quality of teaching, by focusing the education on the achievement of pre-defined learning outcomes, and involving stakeholders (including business community) in the definition and oversight of study programmes. The progress is verified by regular accreditation procedures, obligatory for all higher education providers. Public funding programme for "ordered study specialties" increased the supply of graduates in science and technology areas important for the economy, and financing for innovative study programmes on graduate and postgraduate levels, as well as professional training, was ensured by means of the EU Structural Funds. MNiSW-coordinated competitions promote quality of teaching and innovative study designs. However, some PHEIs assured only formal compliance with the new legal requirements, related to the quality of teaching, without actually transforming their study programmes (procedural changes not accompanied by attitude changes among lecturers). Paradoxically, the availability of additional public funding for selected study programmes distorted the education market, and forced PHEIs to lower study requirements in order to complete the projects and receive cost reimbursements.

(7) Partnerships between higher education institutes, research centres and businesses, at regional, national and international level

The science reform from 2010-2011 established institutional framework supporting science-industry co-operation, including the formation of special purpose companies by PHEIs, academic spin-offs and consortia of business and scientific organisations. There are dedicated funding programmes, supporting commercialisation of research results, including support for university spin-off companies, technology incubators/transfer centres and establishing the profession of innovation brokers, acting as agents promoting and selling/licensing university technologies. VC funds are involved in the evaluation of and financial support for academic innovations in targeted funding programmes. Short-term business secondments are offered to researchers, bringing them closer to business enterprises and jointly work on the development of innovations. MNiSW and PARP co-fund the Polish participation in transnational initiatives, including Horizon 2020 and COSME. PARP offers innovation vouchers, used by business enterprises to purchase R&D services from scientific organisations. Amendments to the Act on Higher Education from 2014, assigning the ownership of academic inventions' IPRs to their creators (scientists, not their employing institutions), are likely to further stimulate the commercialisation of academic inventions. The EU Structural Funds in 2014-2020 (POIR) will support the formation of science-industry consortia (funding eligibility requirement for many types of R&D projects), intensify the co-operation within strategic clusters, facilitate the commercialisation of research results and promote Polish participation in trans-national R&D programmes. In spite of the efforts from recent years, the scale of technology transfer from science to

industry is still perceived as unsatisfactory. The employment mobility between PHEIs/PROs and private sector is not easy due to differing requirements for researchers positions.

(8) Framework conditions promote business investment in R&D, entrepreneurship and innovation

A comprehensive policy framework was introduced by PRP, targeting innovation and entrepreneurship. Enterprises benefit from the availability of private funding and support, including VC funds, New Connect market and KSU network, as well as public funding for VCs from KFK and for incubators/business angels from PARP. Recent governmental efforts to reduce administrative burdens, eliminate excessive bureaucracy and improve business environment, resulted in significant improvements in Poland's position on the World Bank's ranking of ease of doing business. IPRs are respected (but enforcement is less effective), and IPRs protection by business enterprises could be co-funded from public sources. Nevertheless, accounting and tax regulations do not encourage investments in R&D, and VCs with other financial institutions tend to prefer low-risk investments instead of high-tech ventures.

(9) Public support to research and innovation in businesses is simple, easy to access, and high quality

R&I support schemes, offered by PARP, NCBiR and other public organisations, are differentiated and targeting specific business challenges. Support measures address previously identified market failures, to which government agencies are responsive. There were visible and successful attempts at restricting bureaucracy and shortening the time needed to evaluate, contract and offer payments in publicly-funded projects. Individual funding schemes undergo regular evaluations at PARP, NCBiR and NCN. The government plans to ensure complementarity of the EU Structural Funds (POIR) measures to Horizon 2020 support in the 2014-2020 financial perspective. Young innovative companies benefit from a large number of funding opportunities, based on public funds and offered through non-public sector intermediaries (including business incubators, investment funds and business angel networks). Shortcomings include the limited use of FP7 and CIP funding programmes in Poland, but the interest of private sector in trans-national initiatives is increasing. No quantitative targets were set for attracting Horizon 2020 funding to business sector in Poland. Business enterprises used to complain about the bureaucracy and invasive controls of beneficiaries of the EU Structural Funds, but government agencies worked to improve these procedures in recent years.

(10) The public sector itself is a driver of innovation

Many innovations are introduced by public sector organisations, including innovative support instruments for R&I, and some initiatives support the improvement of public procurement (including Sustainable Public Procurement, pre-competitive procurement). Public-private partnerships were introduced by NCBiR as innovative support measures increasing the private co-funding for R&D. However, there are no incentives to use public procurement for promoting innovations.

Non-quantitative criteria are rarely used in public tenders (i.e. in most cases, selection is based on price only). While some public sector organisations (or their parts) are very innovative, others tend to operate in very conservative ways, unwilling to take risks or start novel initiatives, so the overall innovativeness of the public sector remains relatively low. Open access to publicly funded research and public data are still not adequately regulated.

5.2 Structural challenges of the national R&I system

The analysis of the Polish data indicates the following key challenges, faced by the national innovation system.

Structural challenge 1: Limited reporting of business investment in R&D

Polish BERD statistics are unreliable sources of information, due to multiple underlying limitations. Many business enterprises do not understand the concept of "Research & Development", mistakenly associating it with scientific research, contracted to university researchers, and do not consider in-house activities as R&D. This understanding is deeply rooted in traditional divisions from socialist times, and no publicly sponsored information campaigns attempted correct this misunderstanding. In a recent survey commissioned by the European Commission, only 8% companies in Poland declared that they carried out R&D (EC DGCOMM, 2014: T15), but 40% of them introduced product innovations and 49% - service innovations (EC DGCOMM, 2014: T8-T9), and among sources of innovations, companies indicated their own employees (63%), other suppliers (54%) and HEIs/PROs (15%) (EC DGCOMM, 2014: T16-T19). The above-presented data can be interpreted as misinterpretation of the essence of R&D by many respondents, who did not consider efforts by company employees and work on the development or improvement of products and services as falling into the category of Research & Development.

Another source of BERD underreporting is inconsistencies between the national R&D statistics data collection and accounting regulations, as R&D expenditures cannot be directly identified in financial statements and could be classified as several different positions in corporate books throughout the year. Publicly listed companies are not required to report R&D expenditures to investors. Most companies never disclose this information, and data submitted to the national statistical office (GUS) are confidential.

BERD data are collected once per year by GUS by means of 17-pages-long questionnaires, considered too detailed and burdensome by many managers. The data collection system relies on individual submissions (i.e. GUS does not initiate outbound contacts nor sends reminders). As a result, counts of companies returning the questionnaire are rather low. Respondents might also conveniently declare lack of any R&D expenditures, as this eliminates the need to answer further questions of the survey.

Ministry of Environment surveyed the most innovative providers of environmental technologies and discovered that only exactly 5% of them declared any R&D expenditures in 2012, while all of them were actively conducting R&D efforts, funded mostly from private sources (Klincewicz et al., 2013). The suggestions that Poland's BERD is under-reported, were also expressed by the World Bank (Kapil et al., 2012: 9). Many R&D performers have never reported any relevant R&D expenditures, but the details about R&D

expenditures of individual companies are protected by statistical data confidentiality principles, guarded by the Polish law, making cross-verification impossible.

The recent increases in BERD can be attributed among others to the activities of NCBiR, as the agency requests its beneficiaries to adequately report their own financial contributions, supplementing the public co-funding, and reserves the right to control the supporting documents.

In the Polish legal system, business enterprises face no penalties for failing to report or for inadequately underreporting the R&D expenditures, while at the same time, they have no incentives to report them (no related tax benefits, no additional benefits when applying for R&D subsidies). Moreover, the existing accounting and tax regulations might motivate many companies to classify their R&D efforts as expenditures on fixed assets rather than on intangible assets development. Many high-tech companies are suspected not even to know how to classify R&D expenditures, and benefit from the permissible accounting regulations by using an internal chart of accounts, which does not foresee booking R&D expenditures at all.

This lack of reliable BERD statistics presents a problem to policy makers, as meeting the ambitious R&D intensity targets will not be possible without adequate data collection from business enterprises. The actual R&D expenditures of the Polish business sector are most likely much higher than the reported BERD. Even though the Central Statistical Office continuously works on improving the R&D data collection, the problem has rather systemic nature, and could only be addressed by amending accounting regulations, launching an information campaign, linking the annual R&D surveys to existing financial reporting practices and significantly simplifying the contents of obligatory questionnaires. Instead of implementing administrative measures and streamlining the data collection process, the government expressed beliefs that the future implementation of R&D tax breaks would increase the R&D reporting propensity, but the fiscal incentives have not been implemented as of 2015.

Structural challenge 2: Unsatisfactory synergies between the science and industry, restricting the innovative potential of the economy

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. Multiple studies preceding the reform demonstrated the lack of dialogue or co-operation between academics and entrepreneurs. The reform brought about important changes in perceptions, encouraging collaborative projects, and multiple support measures, described in sub-chapters 4.2 and 4.4 target this particular structural challenge.

Nevertheless, the outcomes still remain unsatisfactory. The number of research projects carried out by PHEIs and PROs, contracted by the industry, remains low, even though companies frequently apply for public R&D co-funding by forming consortia with scientific organisations. Counts of joint patent applications are insignificant and only 2.3 per million Polish publications, registered in Web of Science database, were jointly co-authored by academics and business sector representatives, compared with the corresponding ratio of 7.3 for the EU-28 (EC DGEI, 2014: 83).

Business enterprises in 2012 funded only 2.14% of R&D costs at PHEIs, and 9.06% at PROs, while the largest PRO, Polish Academy of Sciences, benefited only from 1.82% of business contributions to its R&D budget (GUS, 2014b). Business enterprises in Poland employed in 2012 in total 1,357 scientists, holding PhDs or academic titles, out of the total population of 70,810 employed scientists with these qualifications (GUS, 2014b). In 2012, altogether only 18.22% of all researchers in Poland were employed by business enterprises (GUS, 2014b), and the share was significantly lower than the 2008 estimate for the entire EU: 45.8% (EC DGRI, 2011: 115).

The disappointing results of academic technology transfer were summarized by the country-wide analysis by the Supreme Audit Office (NIK, 2013), but the analysis was carried out soon after the introduction of 2010-2011 reform, while some new regulations defined by the reform came into force as late as in 2013, so it seems too early for an ex-post evaluation. There are positive tendencies, with improved willingness to co-operate, demonstrated e.g. by a recent survey of business enterprises (KPMG, 2013). The issue of unsatisfactory science-industry collaboration remains nevertheless a structural challenge, which will need to be continually addressed by public policies.

Structural challenge 3: A need to concentrate financial resources on key strategic areas and RDI priorities

In the past, investors and R&D performers were finding it difficult to identify clear priorities in the government's RDI support policies. Even though the policy document KPB (National Research Programme, 2011) declared strategic areas in terms of fields of research or technology types, the directions were general and broadly distributed. A clear and consistent focus of the government, coupled with increased financial support for these key areas, would benefit all participants of the RDI system. The government funded two large-scale technology and science foresight efforts, which initially were not transformed into specific, measurable RDI objectives. The structural challenge is gradually disappearing due to the planning efforts in 2013-2014, involving the identification of smart specialisations on national and regional levels, linked to the preparation of operational programmes based on the EU Structural Funds for 2014-2020. The government defined a list of 19 national smart specialisations (KIS), declaring that part of R&I funding will be concentrated on these areas. In a similar manner, each of 16 Polish regions established an own regional list, defining eligibility of funding for R&D and research infrastructures from the future Regional Operational Programmes. These efforts will bring their first fruits in 2015. Official statistics prove that already in 2012, Polish R&D funding was more concentrated on specific thematic areas than the EU-28 average, and relatively higher financing was allocated to societal challenges, consistent with those identified in Horizon 2020 (comp. Eurostat data presented in sub-chapter 2.2, Table 2), but the specific directions were not adequately communicated by the government. Without the declaration of focusing efforts and resources on specific, well-defined science and technology areas, participants of the innovation system might not understand the R&I priorities of the government. In many cases, the lack of government commitments and related uncertainties discourage R&D performers from investments and in-house development.

Structural challenge 4: Increasing internationalization and attractiveness of RDI system

Polish companies are avid users of foreign technologies. Statistics concerning formal transfers of technologies to industrial enterprises in 2012 document the conclusion of 878 inward licensing agreements, 399 joint R&D projects, 821 acquisitions of means automation (e.g. manufacturing lines) and 592 technical consulting service projects, with technologies supplied mostly by entities from other EU countries (GUS, 2014a: 146). Licence and patent revenues received by Polish companies from abroad were in 2009 over 10 times lower than the EU average, accounting for 0.02% of Poland's GDP (EU-27: 0.21%) (EC DGRI, 2011: 186). Exports of knowledge-intensive services as a share of total service exports (33.05%) also remained lower than for EU-27 (48.13%) (PRO INNO Europe, 2012: 63), while the share of high-tech exports in total exports was 5.2% (EU-27: 15.4%) (GUS, 2013a: 129).

Poland has a very low share of doctoral candidates from other EU countries (EC DGRI, 2011: 274), and almost 10 times less non-EU doctorate students than the EU-27 average (PRO INNO Europe, 2012: 63). The legal framework and financing conditions do not attract experienced foreign researchers, but the availability of specialist research instruments and infrastructure, funded from the EU's structural funds, stimulates short-term visits of international scientists.

The share of Polish publications co-authored with international partners was 28.77% in 2012 and 29.46% in 2013 (SCImago, 2014). The largest academic institutions are highly internationalized – University of Warsaw had 44.5% of publications from 2000-2009 co-authored with foreign scientists, and Jagiellonian University – 39.0% (Klincewicz, 2012), but other institutions are less inclined to co-operate with international partners. Polish researchers maintain the most intensive collaborative ties, evidenced by joint publications, with Germany, France, the United Kingdom, Italy and Spain (EC DGRI, 2011: 187). Counts of patents with foreign co-inventors are low, but the most intensive collaboration concerns Germany, Sweden, France, Italy, Switzerland and the UK (EC DGRI, 2011: 188). It should be emphasized that Polish researchers and inventors have limited ties to the US organisations, compared with their counterparts from other countries.

Altogether 1,728 projects involving Polish researchers were funded by FP7, with 2,222 participant organisations from Poland. By the November 2013, only in 224 projects Polish institutions acted as projects coordinators (KPK, 2013: 3), but the number of Polish business enterprises benefiting from FP7 was still relatively low: only 481 organisations, and Poland benefited in total from 1.14% of all FP7 allocated to beneficiaries from EU-28 (KPK, 2013: 5). Interestingly, the international mobility of Polish researchers employed in higher education sector (interpreted as research or studies abroad for at least 3 months) is close to the EU average (EC DGRI, 2011: 276), but these movements do not contribute to substantial increases in joint research projects or publications.

Dedicated funding instruments support the internationalization of the Polish RDI system, including grants targeting international co-operation, offered by NCN, NCBiR and Polish Science Foundation (based respectively on the science budget and the EU Structural Funds), and in years 2014-2020, the support will be strengthened thanks to dedicated support measures in POIR.

The observed characteristics of Poland's RDI system resemble the performance of developing countries, with business sector focused on adoption of foreign technologies and

researchers maintaining limited links with the international scientific community. In spite of wide availability of funds for international projects and the active international mobility, Poland remains the net payer to the FP7 and does not capitalize on opportunities within the EU. Individual and institutional evaluation frameworks do not reward researchers or institutions for the degree of internationalization, and many PHEIs primarily understand the internationalization as student mobility.

Structural challenge 5: Insufficient R&D efforts of domestic and foreign-owned business enterprises

Stimulation of business expenditures on R&D and in-house technological innovations in business enterprises remains a persistent, structural challenge for the Polish economy. R&D funding of business enterprises has increased in 2012 and 2013, but remains unsatisfactory (even when taking into account the reporting challenges, described as structural challenge no. 1). The absolute BERD at €1,282.74m in 2013 was higher than in other new EU member states, while still significantly lower than the BERD of most of the old EU members (Eurostat, 2014).

In 2012, 2,110 business enterprises declared expenditures on R&D (GUS, 2014b), and only 521 registered purchases of research equipment, classified as fixed assets (GUS, 2014b). Among economy sectors declaring their investments in R&D in 2012, manufacturing accounted for 53.53%, and information and communication sector for 20.34% of total business spending, while agriculture, construction, finance and insurance had only minor importance (GUS, 2014b). Similarly, the R&D personnel in business enterprises concentrates in the manufacturing sector (46.06%) and the information and communication industry (28.50%) (GUS, 2014b). Some sectors, which were key to the Poland's economic growth in the recent years, declare only limited R&D investments and relevant employment.

65.21% of business expenditures on R&D were in 2012 spent by large enterprises, employing 250 or more persons, while medium enterprises (50-249 employees) accounted for 22.60%, small enterprises (10-49 employees) – for 9.28% and micro-enterprises (up to 9 employees) – 2.90% (GUS, 2014b). The ranking of top 1000 European companies based on R&D expenditures of "the 2014 EU Industrial R&D Scoreboard" included only 4 Polish companies, all of them with predominantly local capital (JRC, 2014). Regional distribution of BERD presents additional problems as 34.4% of all business enterprise expenditures on R&D in Poland are spent in Masovia (mostly Warsaw) (GUS, 2013b).

In 2012, 41.1% of R&D investments in business sector were generated by enterprises controlled by foreign capital (GUS, 2014b). Poland experiences a constant influx of foreign direct investments, being one of the most attractive FDI locations in the EU. According to the World Bank estimates, R&D-intensive FDI accounted only for 4.5% of the total FDI in Poland in 2010, compared to 13% in Hungary and 21% in Slovakia (Kapil et al., 2012: 3), but the character of the largest FDIs in Poland gradually evolves towards knowledge-based activities. Little attention is paid to the creation of linkages between the foreign enterprises and local companies or scientific organisations, there are also no dedicated instruments to promote knowledge spill-overs from FDIs.

Table 5. 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) Limited reporting of business investment in R&D	• NCBiR and the Ministry of Environment (GreenEvo programme) requiring their beneficiaries to declare R&D expenditures and reminding of the legal reporting obligations • (Unclear) plans to introduce R&D tax exemptions, expected to motivate companies to adequately report R&D expenditures	Limited impact of the existing policy actions, but positive effects for the concerned business enterprises. Additional efforts needed to streamline R&D reporting, align it with the existing accounting frameworks, carry out information campaigns and define project evaluation criteria for major R&D funding instruments, encouraging applicants to meet their reporting obligations.	-
(2) Limited synergies between the science and industry, restricting the innovative potential of the economy	• 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 • Planned support measures in POIR include preferences for business-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-	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 2010-2014, 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	Evaluation of the RDI 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 too early 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).

Structural challenge	Policy actions addressing the challenge	Assessment in terms of appropriateness, efficiency and effectiveness	Evidence on the impact and outcomes of policy actions
	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 innovativeness, BRIDge • Amendments to the Act on higher education from 2014, facilitating the assignment of IPRs to scientists in order to facilitate their co-operation with industry	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-private partnerships stimulating R&D projects by industry working with academics and VC specialists.	
(3) A need to concentrate financial resources on key strategic areas and RDI priorities	• National Research Programme (KPB), adopted in 2011, perceived as the list of R&D priorities by the government in the pre-2014 period • Strategic research programmes by NCBiR match KPB priorities and focus support on selected technology areas • National Smart Specialisation (KIS) as a concise list of national priorities in applied R&D and technology development adopted in 2014 (resulting from two large-scale foresights for science and industry) • Smart specialization strategies of 16 Polish regions prepared in 2014	In 2013-2014, the RDI policy framework was modified to include strong prioritization through KIS and regional smart specialisation strategies, and significant part of future funding for R&D will focus on technological areas identified as key for the Polish economy. Evaluation of the efficiency and effectiveness is premature in 2014, as the relevant support measures will be enacted in 2015, 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	Evaluation of KIS and regional smart specialisation strategies, prepared by World Bank (unpublished, 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
	• POIR and RPOs will fund projects consistent respectively 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	into account the preferred investment directions. 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. Eurostat data demonstrate that the share of GBAORD allocated to thematically focused R&D in Poland is already higher than the EU-28 average.	
(4) Increasing internationalization and attractiveness of RDI system	• Multiple support instruments, stimulating international co-operation in R&D (MNiSW, PARP) and support planned in POIR • Institutional reform of science and higher education facilitated the employment of foreigners without Polish academic degrees and titles • 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 • Foreign investors, establishing subsidiaries in Poland, can benefit from all policy measures	Poland is not an attractive destination for experienced foreign researchers, doctoral students and postdocs, due to institutional barriers for non-Polish citizens and low income level in the science sector. Nevertheless, Polish researchers increasingly collaborate with foreign experts and this is evidenced by the increases in co-authorship of publications and patents, and involvement in international R&D consortia (even though the extent of these efforts seems unsatisfactory when compared with similar statistics for other EU countries). Poland's share of R&D funding allocated to trans-national initiatives is the highest	Evaluation of Poland's RDI system, involving its internationalisation, carried out by World Bank (Kapil et al., 2012). Analysis of changes in the international co-publications at PHEIs in Poland (Klincewicz, 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
		among the new EU member states. This is not yet matched by Poland's high-tech exports or international technology licensing. Support measures planned in POIR, focused on stimulating innovative exports and encouraging business enterprises to participate in trans-national R&D initiatives, are likely to increase the internationalization. Also, 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.	
(5) Insufficient R&D efforts of domestic and foreign-owned business enterprises	• Observed changes in policy focus from innovation absorption to R&D support, demonstrated in top-level policy documents SIEG, PRP and POIR in 2013-2014 • 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 and sectoral programmes, with disproportionally high	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 - comp. structural challenge 1). 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. NCBiR, the agency appointed to co-ordinate R&D funding in POIR, was	Evaluation of the RDI 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).

Structural challenge	Policy actions addressing the challenge	Assessment in terms of appropriateness, efficiency and effectiveness	Evidence on the impact and outcomes of policy actions
	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 programme), and plans to invest in innovations by Industrial Development Agency (ARP) • Plans to offer tax incentives to R&D performers (declared in PRP, but not implemented)	awarded the title of 'the innovator of the year' by a major Polish business newspaper, which demonstrates the growing confidence of industry in this transformation. Enterprise survey indicated the willingness of companies to further increase their R&D expenditures (KPMG, 2013). A major shortcoming is the lack of implementation of R&D tax breaks, which were promised in PRP, but no further actions were observed in this area.	

Source: own.

5.3 Meeting structural challenges

The policy mix in Poland related to the five identified structural challenges is discussed in Table 5, which lists relevant policy actions, assesses their appropriateness, efficiency and effectiveness, and provides links to relevant evidence (based on evaluations or empirical analyses). The table reveals that structural challenges no. 2-5 have been addressed by the new policy instruments and government initiatives in 2013 and 2014, but the structural challenge no. 1 is still not linked to adequate policy actions.

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Annex 2 - Abbreviations

ACTA	Anti-Counterfeiting Trade Agreement
ARP	Industrial Development Agency (Agencja Rozwoju Przemysłu)
BERD	Business Expenditures for Research and Development
BGK	Bank Gospodarstwa Krajowego
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
HEI	Higher Education Institution
HERD	Higher Education Expenditure on R&D
HRST	Human Resources for Science and Technology
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 Programme 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)
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 (Naczelna Izba Kontroli)
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)
PCT	Patent Co-operation Treaty
PHEI	Public Higher Education Institution
PIR	Polish Development Investments (Polskie Inwestycje Rozwojowe)
PLN	Polish zloty

PMDIB	Polish Roadmap of Research Infrastructure (Polska Mapa Drogowa Infrastruktury Badawczej)
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
RDI	Research and development and innovation
RIS3	Research and Innovation Strategies on Smart Specialisation
RPO	Regional Operational Programme (Regionalny Program Operacyjny)
S3	Smart Specialisation Strategy
S&T	Science and technology
SIEG	Strategy for Innovation and Efficiency of the Economy (Strategia Innowacyjności i Efektywności Gospodarki)
SME	Small and Medium-sized Enterprise
VC	Venture Capital

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