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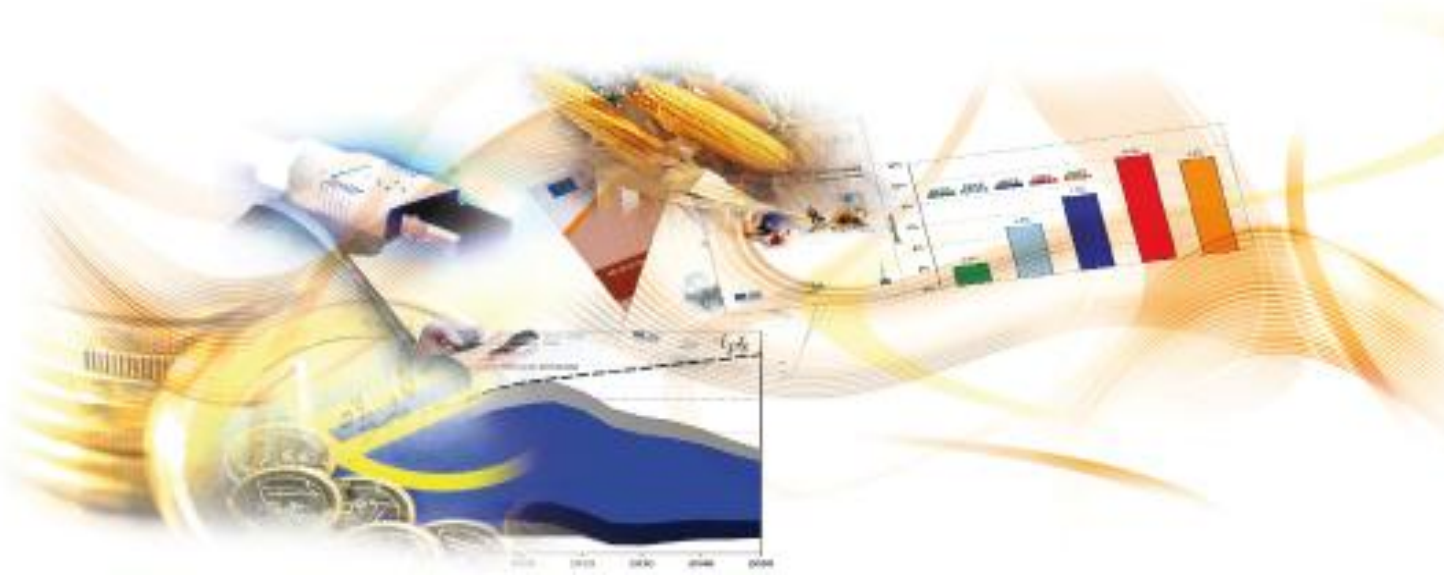

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The Country Report 2012 builds on and updates the 2011 edition. The report identifies the structural challenges of the national research and innovation system and assesses the match between the national priorities and the structural challenges, highlighting the latest developments, their dynamics and impact in the overall national context.

The first draft of this report was produced in December 2012 and was focused on developments taking place in the previous twelve months. In particular, it has benefitted from the comments and suggestions of Krzysztof MIESZKOWSKI from JRC-IPTS. The contributions and comments from DG-RTD are also gratefully acknowledged.

The report is currently only published in electronic format and is available on the ERAWATCH website. Comments on this report are welcome and should be addressed to jrc-ipts-erawatch-helpdesk@ec.europa.eu.

EXECUTIVE SUMMARY

Poland benefits from the constant **economic growth** and **gradual improvements of R&D-related indicators**. **GERD** as percentage of GDP was 0.68% in 2009, 0.74% in 2010, and 0.77% in 2011, but still remaining significantly **below the target level** of 1.70%, expected in 2020. The main source of R&D funds remains the government. **BERD** in 2011 was **only 0.23% of GDP** (EU: 1.26%), but the business expenditures on R&D gradually increased in the recent years. **Enterprises controlled by foreign capital** accounted in 2011 for 45.4% of R&D investments in business sector, 66.0% of business expenditures on R&D came from **large enterprises** and small and micro-enterprises were not a significant source of innovations, contributing only 13.5% of BERD. The weaknesses of the Polish innovation system, identified by "*Innovation Union Scoreboard 2011*", include: the lack of *"open, excellent and attractive research systems"*, limited number of **innovative companies**, **unsuccessful linkages** and entrepreneurship efforts, as well as scarce **intellectual assets** (patents, trademarks and designs).

In 2010, Ministry of Science and Higher Education initiated a wide-ranging **reform of science and higher education** institutions, and the transformations in 2012 established the full operational capacity of two **R&D funding agencies**: NCN (fundamental research) and NCBiR (applied research). Over 100 public higher education institutions (PHEIs) and over 200 public research organisations (PROs) undergo regular **performance evaluations**, managed by a newly established committee KEJN, with focus on quantifiable results and internationalization (first evaluation based on the new rules is scheduled for 2013). The institutions are also expected to participate in competition-based distribution of research funds. By 2020, the government declared to distribute 50% of its entire science budget through competitive mechanisms, but already in 2012, the budgetary plans earmarked 63.79% of all science funds to be divided through competitions, including programs co-ordinated by NCN and NCBiR (MNiSW 2012).

Ministry of Economy published in 2012 the final draft of the ***Strategy for the Innovation and Efficiency of the Economy for the years 2012-2020*** (SIEG). SIEG sets quantifiable objectives, related to R&I funding and outputs in the national system of innovations, as well as delegates specific tasks to other governmental institutions. Critics suggest that the prescribed actions are not sufficiently specific, and expected indicator values are based on wishful thinking, not linked to the actual policy measures. SIEG was adopted by the government in early 2013. The Council of Ministers issued in 2011 another major policy document, the ***National Research Program*** (KPB), which was supposed to set national R&D priorities, but these priorities turned out to be very general and all-encompassing. Ministry of Economy prepared the draft ***Enterprise Development Programme*** (PRP), focused on support for RDI activities of business enterprises, and published it for public consultations in early 2013.

Polish efforts targeting **smart specialization** are rooted in multiple foresight projects, commissioned by Ministry of Science and Higher Education and Ministry of Economy. The latest relevant endeavour was "*Technological Foresight of Industry – InSight 2030*", commissioned by Ministry of Economy, which yielded a proposal for 35 competitive industrial specialties, and 127 key technologies, expected to increase the competitiveness and innovativeness of Polish industrial companies. The outcomes are difficult to implement, with an excessive number of

possible specialities, lack of focus and real prioritization. The government confirmed in "*National Reform Programme Europe 2020*", submitted to the European Commission in April 2011, that "*in a longer perspective, it would also be necessary to specify the so called smart specialization plans for the country and for the regions*", but these plans have not yet been adequately prepared and implemented.

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

(1) **Low levels of business investment in R&D and in-house technological innovation** – with limited interest of business enterprises in R&D activities, low BERD/GDP ratios and small number of innovating enterprises, accompanied by the preference for acquiring foreign technological solutions instead of in-house R&D.

(2) **Limited synergies between the science and industry, restricting the innovative potential of the economy** – rooted in the traditional divide between academic institutions and business organizations, and difficult to overcome due to unfavourable perceptions and attitudes, even though the recent science and higher education reforms encourage scientists to co-operate closely with the industry.

(3) **A need to concentrate financial resources on key strategic areas and RDI priorities** – with no clear prioritization or preferences for R&D directions expressed by government organizations, participants of the RDI system are disoriented and uncertain about possibility of receiving future support for their potential ventures.

(4) **Increasing internationalization and attractiveness of RDI system** – as the outputs of Poland's RDI system are below the EU-27 average (scientific publications, citations, patents, FP7 participation), and foreign companies regard Poland mostly as low cost labour market, not source of knowledge and technology expertise.

(5) **Inducing knowledge spill-overs from foreign direct investments** – related to the lack of dedicated policies, attracting investments in R&D, as Poland still focuses on creating jobs through FDI instead of creating knowledge-based jobs.

The RDI policy mix evolved in recent years and in particular, the structural reforms of science and higher education from 2010-2011 yielded substantial improvements in its structure. The **portfolio of instruments is very comprehensive**, but several intervention areas seem not to have been adequately addressed: R&D project loans (as the instruments available in 2012 focus on subsidies instead), R&D friendly procurement, reform of IPR regulations (including the establishment of dedicated IPR court), loan and equity guarantees for R&D investments (with the limited availability of instruments, supported by the EU Structural Funds), R&D tax measures (as only tax incentives for technology implementation – not development – are prevalent), R&D-specific employment policies and subsidies for hiring R&D personnel.

The existing policies demonstrate **alignment with some of ERA's priorities**: (1) "*More effective national research systems*", (2) "*Optimal transnational co-operation and competition*", (4) "*Gender equality and gender mainstreaming in research*", and (5) "*Optimal circulation and transfer of scientific knowledge*". More problematic is the priority (3): "*An open labour market for researchers*", as current policy measures including legislations cannot significantly improve the attractiveness of the Polish research market due to low wages and conservative academic traditions.

The recommended evolution of the RDI policy mix could include the increased support for business enterprises performing R&D, with **tax incentives for R&D performers**. There is also a need to supplement R&D subsidies by **revolving financial instruments** (including loans), which would stimulate further BERD increases, and the need has already been acknowledged by policy makers.

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1 INTRODUCTION

Poland is the 7th largest economy in the EU-27, accounting for 2.92% of EU-27 GDP. With 38.5m inhabitants, it represents 7.6% of EU-27 population. The country experiences positive **GDP growth** rates since the 1990s and its economy increased by 1.6% in 2009, 3.9% in 2010, 4.3% in 2011 and 1.9% in 2012, being one of the fastest growing EU-27 economies in the recent years (Eurostat, 2012).

Poland's **GERD** was €2,095.83 in 2009, €2,607.50 in 2010 and €2,836.16 in 2011, growing by 137.02% between 2000-2011 and by 87.51% between 2006-2011 (Eurostat, 2012). Between 2000 and 2011, GERD in Poland converted to Euro (€)[1] was increasing at an average annual rate of 8.9%, exceeding the rate for EU-27 (3.78%), and the most impressive growth was demonstrated in 2010 (24.41%) and 2011 (8.77%) (Eurostat, 2012). GERD per capita was €55 in 2009, €68.3 in 2010 and €74.2 in 2011, up by 139.35% from 2000 levels and exceeding the increase of GDP per capita of 95.92% for the same period (Eurostat, 2012). For years 2006-2010, GERD per capita went up by 87.37%, while GDP per capita – by 35.21% (Eurostat, 2012). In spite of this increase, the indicator remains low in comparison with EU-27 average.

GERD as percentage of GDP was 0.68% in 2009, 0.74% in 2010, and 0.77% in 2011, below the national targets for Poland and the EU-27 average. The main source of R&D funds in 2011 was the government, contributing 55.80% of GERD (compared with the EU's average for 2010 of 34.6%), while foreign funds for R&D build up 13.39% of GERD (EU-27 in 2010: 8.9%) (Eurostat, 2012). **GOVERD** for 2011 was 0.26% of GDP (EU-27: 0.26%), **HERD**: 0.27% of GDP (EU-27: 0.49%), and **BERD**: 0.23% of GDP (EU-27: 1.26%) (Eurostat, 2012). Nevertheless, the total value of R&D expenditures is substantial, and Poland's GOVERD belongs to the largest in the EU, while BERD of €854.63m in 2011 exceeded R&D expenditures of business enterprises in other new EU member states, except for the Czech Republic, but was significantly lower than in the old EU member states (Eurostat, 2012).

In 2011, **2,200 organisations registered expenditures on R&D** (up by 100.5% from 2005, 24.5% from 2010), including 1,402 business enterprises, 197 HEIs and 441 government units (including PROs) (GUS, 2012b: 411). Enterprises controlled by foreign capital accounted in 2011 for 45.4% of R&D investments in business sector, and 66.0% of business expenditures on R&D came from large enterprises with 250 or more employees (GUS, 2013b). Small and micro-enterprises are not a significant source of innovations, contributing in 2011 only 13.5% of BERD (GUS, 2013b), with only 17.55% of SMEs introducing product or process innovations (EU-27: 34.18%) (PRO INNO Europe, 2012: 63). In 2011, 105 public higher education institutions (PHEIs) and 207 public research organisations (PROs) were actively conducting R&D activities. PHEIs included 18 universities, 18 technical universities, 6 agricultural universities, 9 medical universities and 9 maritime & defence universities (GUS, 2013b). The largest PRO is Polish Academy of Sciences, encompassing multiple research institutes. Private

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

higher education institutions play a marginal role in the R&D arena (both in terms of R&D expenditures – 6.7% of HERD - and outputs), focusing on teaching.

Human Resources for Science and Technology (HRST) aged from 15 to 74 years amounted in 2011 to 7,280,000 persons, including 47.87% women (Eurostat, 2012). Total R&D personnel (absolute numbers) in 2011 consisted of 134,551 employees (40.55% women), and R&D personnel of business enterprises included 24,047 persons (21.52% women) (GUS, 2012b: 412). Among the R&D personnel, researchers accounted for 64,133 persons and 9,576 employees in business enterprises (GUS, 2012b: 411). The share of people employed in high-tech sectors in the total employment in 2011 was: 2.7% for Poland and 3.8% for the EU-27 (Eurostat, 2012).

There were altogether 1,764,060 **students** in 2011, 497,533 higher education graduates (64.2% women) (GUS, 2012b: 340, 343) and 40,263 doctoral students (GUS, 2012b: 348). Poland accounts for approximately 11.4% of the EU-27 student population (ISCED 5-6) (GUS, 2012a: 306). The share of students in the population aged 20-29 is relatively high in Poland at 37.0%, compared with the EU average of 29.6% (GUS, 2012a: 306). The number of new doctoral graduates (ISCED 6) per 1000 population aged 25-34 is 0.8, which is lower than for EU-27 (1.5) (PRO INNO Europe, 2012: 63). Poland also has a very low share of doctoral candidates coming from other EU countries (EC DGRI, 2011: 274), and almost 10 times lower share of non-EU doctorate students than the EU-27 average (PRO INNO Europe, 2012: 63). Participation in adult lifelong learning initiatives is also lower than in many other EU countries – 4.7% of population aged 25-64, compared with 9.3% for EU-27 (EC DGRI, 2012: 105).

Citable **scientific publications** with at least one author with Polish affiliation, registered in Scopus bibliographic database, add up to 24,129 publications in 2009, 27,158 in 2010 and 27,822 in 2011 (SCImago, 2012). For the period of 1996-2011, an average Polish publication was cited 7.07 times (does not include documents not cited at all), and h-index (Hirsch index for the country was relatively low at 281, but higher than for all new EU member states (SCImago, 2012). 29.18% of Polish publications were co-authored with international partners (SCImago, 2012). Only 5.7% of Polish scientific publications were in 2009 among the 10% most cited publications worldwide (EU average: 11.6%) (EC DGRI, 2011: 186). In 2000-2008, Poland experienced an average annual growth in scientific publications of 8.0%, compared with the EU's 5.1% (EC DGRI, 2011: 139). Only two Polish universities were included in the 2012 Academic Ranking of World Universities by Shanghai Jiao Tong University (www.arwu.org) - University of Warsaw and Jagiellonian University, Cracow.

Polish Patent Office received the following numbers of **patent and utility model applications** from domestic applicants: 4,082 in 2010, 4,818 in 2011 (UPRP, 2012: 48) and 5,348 in 2012. 40.7% of applications in 2011 were filed by business enterprises, and 40.4% by PHEIs and PROs (UPRP, 2012: 49), in many cases not interested in commercialization of the inventions, but regarding the filings as the fulfilment of their institutional evaluation requirements. 12 top patent applicants in 2011 were public universities, and subsequent ranking positions were taken by PROs (UPRP, 2012: 49). The Office issued the below-listed numbers of patent and utility model certificates to domestic entities: 1,834 in 2010 and 2,487 in 2011 (UPRP, 2012: 52). 400 Polish patent were filed in the **European Patent Office** (EPO) in 2011 and 552 in 2012, with 45 patents granted to entities from Poland in 2011 and 80 in 2012 (EPO, 2013), and Polish

applicants filed 235 **PCT applications** at the World Intellectual Property Organization in 2011 (WIPO, 2012: 174). The patenting activity is limited in comparison to larger EU economies.

New-to-market and new-to-firm products accounted in 2010 for 9.84% of sales of Polish firms (EU-27: 13.26) (PRO INNO Europe, 2012: 63), high-tech exports in 2011 built up 5.2% of total exports (EU-27: 15.4%) (GUS, 2013a: 129), exports of knowledge-intensive services added up to 33.05% of total service exports (EU-27: 48.13%) (PRO INNO Europe, 2012: 63) and revenues from patents and licences from abroad were only 0.02% of Poland's GDP (EU-27: 0.21%) (EC DGRI, 2011: 186).

Poland is divided into 16 voivodeships, and the **regional diversity** is mirrored by the differences in intramural expenditures on R&D. In 2011, Masovian voivodeship (with the country's capital Warsaw) had the highest GERD per capita (€215.2), followed by Lesser Poland (€87.9), and other regions registered much lower expenditures (GUS, 2012c: 3). 24.8% of entities performing R&D in 2010 were located in Masovia, 13.2% in Silesia, 9.5% in Greater Poland, 9.1% in Lesser Poland and 8.2% in Lower Silesia (GUS, 2012a: 246). R&D personnel is concentrated in Masovian voivodeship (33.1%) and Lesser Poland (10.8%) (GUS, 2012a: 292-293). In 2012, majority of funds for R&D projects from MNiSW and its agencies, were distributed to applicants from Masovia, and Lesser Poland (MNiSW, 2013: 35).

Based on the total counts of publications in 2011, the dominant **fields of research** in Poland were: medicine, physics and astronomy, biochemistry, genetics and molecular biology, chemistry and engineering (SCImago, 2012). The fields having the highest impact (citations from 1996-2011) were: chemistry, decision sciences, earth and planetary sciences, materials science, mathematics, pharmacology, toxicology and pharmaceutics, as well as physics and astronomy (SCImago, 2012).

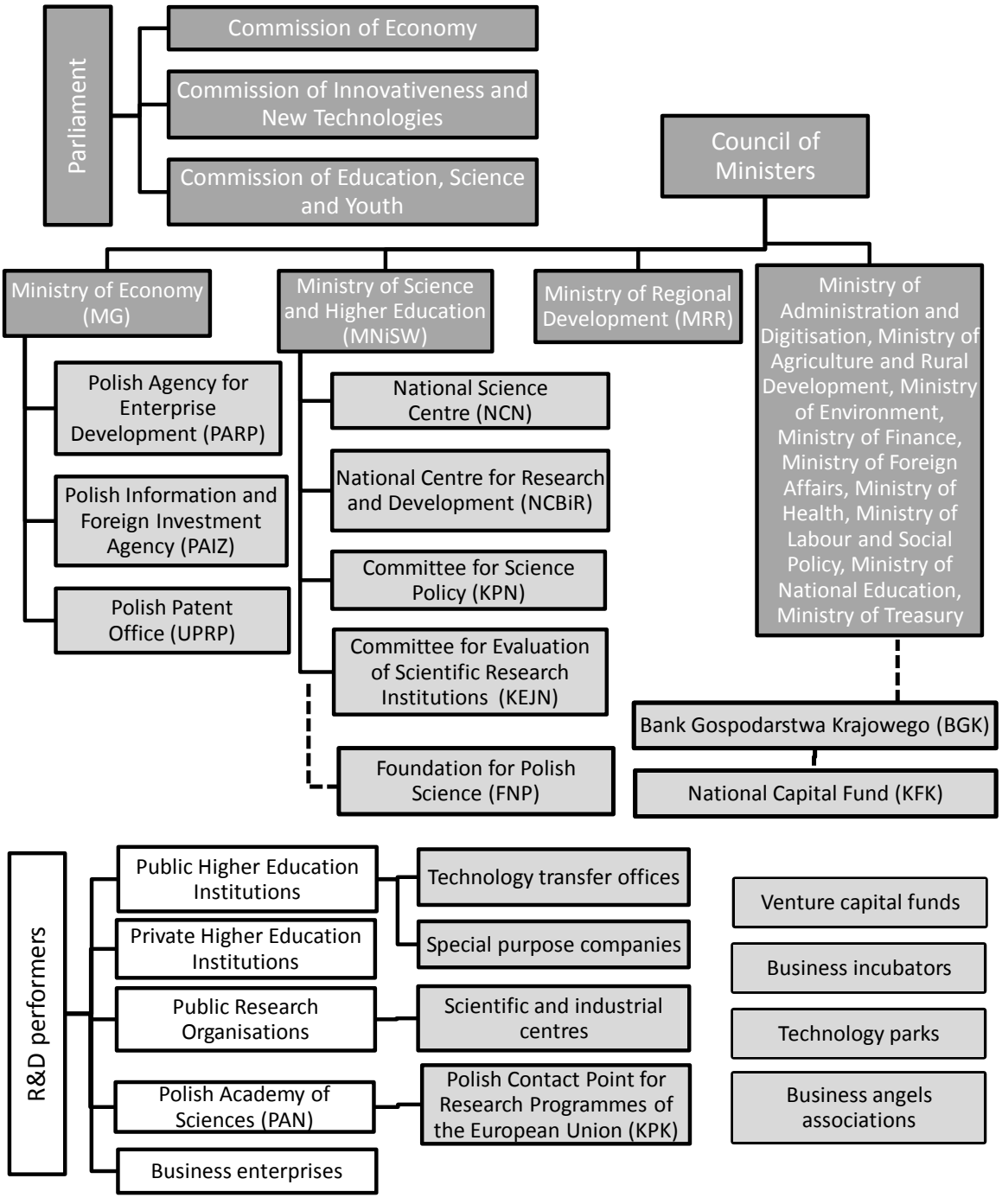
High-tech and high-medium **technology sales** in 2011 were dominated by computers, electronics products, optical instruments, electrical equipment, chemicals, motor vehicles and other machinery and equipment (GUS, 2013b). **Technology exports** included also telecommunications, aerospace solutions and scientific instruments (GUS, 2013b).

Among **R&D spenders** from the business sector in 2011, most active were: automotive companies, electrical equipment manufacturers, industrial machinery, metallurgy, chemical companies, pharmaceuticals, rubber and plastic products manufacturers, as well as producers of computers, electronic and optical equipment (GUS, 2012b: 420-421).

"Innovation Union Competitiveness report" by the European Commission, which divides all EU member states into 9 groups based on their knowledge capacity and economic structure and assigns Poland to the group displaying the worst performance, alongside with Bulgaria, Romania, Turkey and Croatia (EC DGRI, 2011: 430). "Innovation Union Scoreboard 2011" promotes Poland to the group of "moderate innovators" and outlines the major strengths of its RDI system: human resources (measured by the availability of specialists and graduates), finance and support (including R&D expenditures and venture capital finance), firm investments and effects on the national economy (PRO INNO Europe, 2012: 44). Nevertheless, with the exception of human resources, the remaining strengths seem relatively insignificant in comparison with other EU countries. The identified weaknesses of the Polish innovation system are: lack of "open, excellent and attractive research systems", limited number of innovative companies, unsuccessful

linkages and entrepreneurship efforts and scarce intellectual assets (including patents, trademarks and designs) (PRO INNO Europe, 2012: 44).

Figure 1: Poland's RDI governance system.



Source: by the author

Figure 1 presents an overview of Poland's **research and innovation system**, outlining its main actors. The Parliament as the legislative body and the Council of Ministers as the executive shape the relevant national policies. Ministry of Economy (MG) defines the strategies related to innovativeness and supervises three government agencies: Polish Agency for Enterprise Development (PARP), supporting enterprises based on funds from the state budget and the EU

Structural Funds, and through involvement in international projects, including EEN and CIP, Polish Information and Foreign Investment Agency (PAIZ) attracting foreign investors, and Polish Patent Office (UPRP). PARP co-ordinates the National Service System for Small and Medium-Sized Enterprises (KSU), a network of organisations providing free consulting and training services for SMEs, as well as loans and credit guarantees, sponsored by the EU Structural Funds. Ministry of Science and Education (MNiSW) manages the science budget and supervises two key fund distribution agencies: National Science Centre (NCN), financing basic science projects, and 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. MNiSW uses the advice of several specialized committees, including Committee for Science Policy (KPN) and 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.

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. Ministry of Regional Development (MRR) 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. Several other ministries have dedicated programs, stimulating innovations and research projects in relevant sectors. Poland also has a state-owned bank, Bank Gospodarstwa Krajowego (BGK), which supports innovative ventures by means of credits and venture capital investments through its VC arm, National Capital Fund (KFK). The World Bank characterised the innovation support system as overly complex, with responsibilities shared among too many government agencies, and high administrative costs resulting from this "institutional disequilibrium" (Kapil et al., 2012: 39). At the same time, the system is going through major changes due to the science and higher education reform and the preparations for new institutional structures, supporting the absorption of the EU Structural Funds in 2014-2020.

R&D performers include: Public Higher Education Institutions (PHEIs), 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 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, establishing linkages between research institutes and business enterprises. PAN manages the Polish Contact Point for Research Programmes of the European Union (KPK), facilitating the participation of Polish scientists in FP7 and other programmes. Main Council of Science and Higher Education (RGNiSW) is the official representation of PHEIs, PROs and PAN, and Conference of Rectors of Academic Schools in Poland (KRASP) represents the public and private universities.

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.

2 RECENT DEVELOPMENTS OF THE RESEARCH AND INNOVATION POLICY AND SYSTEM

2.1 National economic and political context

Polish economy was spared in the Eurozone crisis and benefited from an investment boom before the 2012 UEFA European Football Championship, the largest international event held in Poland so far. The economic optimism gave way to more cautious attitudes among business sector representatives after the games, and subsequent investments in infrastructure declined, impacting construction companies, and monthly unemployment rates oscillate around 12-13%. GDP growth forecasts are positive: 2.4%, according to the European Commission forecast from autumn 2012, one of the highest rates in the EU.

Parliamentary elections from October 2011, when Poland was holding the Presidency of the Council of the European Union, assured the continuation of the previous government coalition of the centre-right Civic Platform (PO) and the agrarian Polish People's Party (PSL). Ministries key for the innovation policies were mostly unaffected by the government change. However, due to internal changes within PSL, in November 2012 the Deputy Prime Minister and Minister of Economy resigned, and the personal change opened new opportunities to re-evaluate the Ministry's plans of action.

In July 2012, the largest Polish ICT services company Asseco lost its bid for a major system implementation project in Poland and its president wrote a letter to the Prime Minister, which was soon published in the national press, and in which he complained about the lack of genuine support for Polish R&D performers and preferences for foreign suppliers in public tenders (Jedliński, 2012). The event spurred further debates and stimulated the criticism of the current RDI policies, especially the lack of dedicated pre-commercial procurement regulations.

In November 2012, Poland joined the European Space Agency (ESA), and PARP became the Polish contact point for companies, interested in participation in dedicated ESA tenders for space R&D projects, scheduled to commence in 2013.

In 2011 and 2012, significant changes in the higher education and science were introduced as part of the major sectoral reform. Polish public opinion was initially highly critical of the reform, but these negative opinions were often inspired by scientists, dissatisfied with the competitive and performance-based aspects of the newly introduced institutional regulations.

In early 2012, public awareness of intellectual property rights issues increased due to visible protests against the Anti-Counterfeiting Trade Agreement (ACTA), and the Polish government halted its ratification. A corresponding process concerned the proposed regulations creating unitary patent protection within the EU, which was fiercely opposed by industry associations and patent attorneys, and the analysis of economic impacts, ordered by the government from a major

international consulting firm, pointed to substantial costs, which the Polish economy would incur from the accession to the proposed system (Deloitte, 2012).

In spring 2012, the European Commission temporarily suspended the certification of expenditures on large investments and e-government projects, supported from the Operational Program Innovative Economy (POIG), respectively priorities 4.5 and 7. The action was triggered by an investigation, launched by Poland's justice system with reference to several large ICT projects in the government sector, and the funding flows were fully reinstated after additional explanations from the Polish side.

Meanwhile, Poland prepares for the new EU budget (2014-2020), intensifying work on the Operational Program Smart Development (POIR), which is expected to focus on innovations rather than infrastructure, support development of technologies rather than their implementation, and be guided by the principles of smart specialization.

2.2 Funding trends

In reply to *Europe 2020* strategy, MNiSW prepared a forecast of GERD to GDP ratio for Poland in 2020, with values ranging from 1.08% to 1.96%, and declared "most likely" target value of 1.70%, with 50% of GERD financed by business enterprises (MNiSW, 2011b; comp. also: Republic of Poland, 2011: 47). The forecast seems overly optimistic, as it is based on the assumptions of the key role of R&D in government policies and positive effects of the science and higher education reforms, initiated in 2010-2011.

Table 1 presents the key R&I funding indicators for Poland, outlining their continuous improvements, which nevertheless happen at a slow pace. The science and higher education reforms from 2010-2011 are likely to induce further increases in the coming years, by encouraging the involvement of the private sector in R&D activities.

Table 1. R&D funding trends in Poland.

	2009	**2010**	**2011**	**EU27**
GDP growth rate	1.60	3.90	4.30	- 0.3 (2012)
GERD (% of GDP)	0.67	0.74	0.77	2.03 s (2011)
GERD (euro per capita)	55.0	68.3	74.2	510.5 s (2011)
GBAORD - Total R&D appropriations (€ million)	1,051.67	1,891.48	1,630.59	91,277.1 (EU-27 total 2011)
R&D funded by Business Enterprise Sector (% of GDP)	0.19	0.20	0.23	1.26 (2011)
R&D performed by HEIs (% of GERD)	37.06	37.19	35.10	24% (2011)
R&D performed by Government Sector (% of GERD)	34.31	35.89	34.53	12.7% (2011)
R&D performed by Business Enterprise Sector (% of GERD)	28.50	26.62	30.13	62.4% (2011)
Share of competitive vs institutional public funding for R&D	97.07%	144.15%	180.91%	n/a

s - EUROSTAT estimate

Data Sources: EUROSTAT, March 2013; Ministry of Science and Higher Education

The science budget of 2012, according to the budgetary plan (MNiSW, 2012), was €1,552.7m (excluding R&D-related expenditures of other public administration institutions, defence, culture and national heritage), with 79.42% covered from the state budget and 20.58% from the EU Structural Funds. 32.84% of the budget were allocated to institutional funding, divided based on multiple criteria, including institutional evaluations and scientific rankings. €971.3m (63.79% of the science budget) were distributed through competitions as research grants for R&D projects, research infrastructure, promotion of science, as well as scientific scholarships awards. €38.2m (2.51%) were dedicated to the international scientific and technical co-operation of Polish researchers, with most of these funds distributed through open competitions.

By 2020, the government plans to distribute 50% of the entire science budget through NCBiR (dealing with applied research) and NCN (focused on basic research), by means of competitive mechanisms. In 2012, NCBiR was managing 40.15% of the science budget and NCN - 14.12%. When administrative costs were excluded, NCBiR and NCN were distributing altogether 52.65% of the science budget through R&D grant competitions. Funds distributed by NCBiR are clearly focused on specific research themes, in accordance with precisely defined grant programs, while NCN assigns financial resources based on the bottom-up approach and evaluation of all submitted project proposals.

In 2012, MNiSW and its agencies allocated funds to 3,215 new R&D projects (MNiSW, 2013: 31). There was a significant increase in funding for applied research through NCBiR, which supported 405 projects (€225.5m) in 2011 and 743 projects (€660.8m) in 2012 (MNiSW, 2013: 32, 34). Basic research funding, distributed by NCN, went up as well – from 1,852 funded projects (€122.1m) in 2011 to 2,226 projects (€238.2m) in 2012 (MNiSW, 2013: 32, 34).

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 2011 (GUS, 2012b: 416). In the 2012 science budget, €80m were reserved for R&D infrastructure investments (MNiSW, 2012).

R&I funding is mostly distributed through subsidies, and fiscal instruments such as tax incentives are not popular – in 2011, only 97 companies resorted to tax exemptions related to the implementation of new technologies (MF, 2012: 5), but the number tripled compared with 2010 (MF, 2011: 17). Unfortunately, the existing tax exemptions support the acquisition of technologies or related services, and might discourage in-house R&D. This characteristic of Poland's fiscal system differs from other EU countries, where tax regulations are used to stimulate intramural research efforts. Particularly worrisome is the relatively low BERD, which is constantly increasing, but at a very slow pace. Newly introduced R&I support instruments stimulate the financial contributions of business enterprises, and NCBiR introduced several grant programs, combining private and public finance with 50% of funds covered from the state budget, 50% coming from private sponsors and additional requirements for own contributions by the grant beneficiaries in the range of 10-40%, thus multiplying the necessary private funding for individual projects. While preparing the future distribution of the EU Structural Funds, Ministry of Regional Development (MRR) considers the use of loans to supplement the

subsidies and analyses the possibility of establishing more complex schemes, involving participation of business partners and joint financing.

2.3 New policy measures

The restrictive fiscal policy of the Polish government spared R&I funding from any budget cuts, but delayed the introduction of new measures such as additional tax reductions for R&D performers. The EU Structural Funds (2007-2013), dedicated for the support of innovative activities in Poland, are gradually becoming depleted, but the government introduced new initiatives, funded from the state budget. In consequence, there was no observable decrease in the availability of funding for R&D projects and innovative ventures. The government introduces however a new fiscal measure, coming into force in 2013 – so far, **tax deductible expenses of creators have amounted to 50% of their revenues**, and the important tax deduction has benefited among others researchers, but from 2013 on, an upper limit on the level of deductions will be introduced, in consequence reducing income of many academics.

Policy debates emphasized the benefits of credits instead of grants, as instruments stimulating private sector R&D investments. In 2011, legislation concerning **the Technological Credit** was amended to increase its accessibility and the modified instrument became popular among SMEs. Most importantly, the term 'new technology' used by the legislator was extended to incorporate not only patented technologies, but also know-how and other forms of technical knowledge, related to innovative solutions. PARP launched in 2012 **a new program, supporting the first implementations of patented inventions**, filling in an important funding gap in the innovation cycle, usually referred to as "the valley of death", and helping entrepreneurs commercialize their technical solutions. In March 2013, NCBiR started a similar pilot project DEMOSTRATOR+, funding the development and demonstration of solutions based on research results. NCBiR introduced also in 2012 numerous new programs, targeting specific applied research themes and stimulating co-operation between science and industry.

Major changes were introduced in the public R&D sector, resulting from numerous legislations enacted in 2010 (science reform) and 2011 (higher education reform) – altogether 8 laws and 92 ordinances. The system relies on two funding agencies – National Science Centre (NCN), focused on fundamental research, and National Centre for Research and Development (NCBiR), concentrating on applied research. Both distribute grants in open and transparent competitions, and while their initial funding corresponds to about 20% of annual science budgets, the laws stipulate that by 2020, 50% of science budget will be distributed by NCN and NCBiR. Both agencies are independent from any direct government influences, with governing bodies consisting of scientists and stakeholders. The Council of NCBiR, with equal representation of experts from business, science and government, was tasked with setting applied research programs, thus performing one of the most important roles in the Polish innovation system. In 2011, NCBiR was also tasked with management of R&D-related programs, financed from EU Structural Funds. The Centre initiated co-operation with industry and other government institutions – good examples are **joint programs with the aviation industry** (research projects co-funded by NCBiR and business), **Industrial Development Agency ARP** (support for new shale gas-related technologies), **National Fund for Environmental Protection and Water Management NFOŚiGW** (support for development and implementation of eco-innovations).

Other targeted programs, coordinated by NCBiR, address the development of **new energy technologies, improvement of mining safety, energy efficiency in buildings, support for innovative drugs or non-ferrous metals research**. The Centre was also quick in its reaction to the growing popularity of **new semiconducting material graphene** and established a dedicated financial support instrument, thus capitalizing on existing expertise of Polish researchers in this emerging area. NCBiR programs require financial contributions from applicants, and most funds are equally available to business enterprises, HEIs and PROs. NCBiR supports also **commercialisation of R&D results** by means of programs BroTech (support for technology brokers), SPIN-TECH (funding for companies, established by PHEIs and PROs to transfer technologies) and pilot program BRIdge VC (combining private and public funding for innovative, high-tech ventures). The Centre initiated in 2012 a program called "GO_GLOBAL.PL", supporting firm commercializing R&D outcomes in international markets, and established partnership with a leading tech start-up accelerator in Silicon Valley to help Polish companies gain access to the US market. In January 2013, Ministry of Economy launched a similar initiative, Silicon Valley Acceleration Centre (SVAC), in partnership with another technology accelerator in San Jose, CA. NCBiR prepared also a new program STRATEGMED, committing €86m in 2013 to fund projects related to lifestyle diseases.

The Act on the Principles of Financing Science from 2010 delegated the responsibility for setting the National Research Program to the Council of Ministers. It established financing modalities for NCN and NCBiR, assuring gradual increases in the allocated funding. **The government declared additional financial support for institutions participating in international research programs.** MNiSW and PARP offer co-financing to Polish organisations, acting as coordinators of international projects, respectively to scientific organisations and SMEs. The government stipulated that the intellectual property rights to inventions, created in the course of R&D projects financed by public funds, remain with the R&D performing institutions unless the rule is not overridden by another agreement between the donor and the recipient of funds. This important regulation facilitates future commercial uses of technologies, developed with public support.

PHEIs were obliged to introduce intellectual property management regulations, guaranteeing that inventions and research outcomes are controlled by the universities, and to **establish special purpose companies**, dealing with transfer of university technologies to industry or acting as parent companies for academic spin-offs. The start-up costs of these technology transfer companies will be covered by the newly established program SPIN-TECH, managed by NCBiR. PROs were in turn encouraged to establish co-operative agreements with industrial companies, dubbed 'scientific- industrial centres'.

The legislations reinforced the system of academic representation in the science and higher education. The status of Polish Academy of Sciences (PAN) as the major research institution was maintained, certain government tasks related to the science system were delegated to PAN, but at the same time PAN institutes were subjected to regular audits and evaluations. PROs were reoriented towards R&D co-operation with industry as the primary objective, with prescribed rules concerning reorganization of the poorly performing ones. PHEIs were expected to combine research and teaching, with the exception of the State Schools of Higher Vocational Education, restricted to instruction only, but in close co-operation with local stakeholders, including employers. PROs are represented by the Main Council of the Research Institutes

(RGIB), PROs and HEIs – by the Main Council of the Science and Higher Education (RGNiSW), and HEIs can also form conferences of rectors as their representing bodies. The Committee for Scientific Policy advises the Minister in matters related to the scientific and innovation policy, science budget and funding priorities, as well as issues opinions about draft legislations, work plans and annual reports of NCN and NCBiR.

The new legislations earmark specific funds for young, early stage researchers and offer additional support for career development. **Scientific promotion procedures were streamlined**, with stronger focus on research achievements and elimination of non-scientific assessment elements. Academic institutions started receiving institutional **funds, dedicated for doctoral students and PhDs younger than 35 years**.

New grant application rules require **the submission of project descriptions in English** (with the exception of some disciplines), so that they can be reviewed by international domain experts. Grant application assessments and evaluation of research institutions use among others **bibliometric indicators**, including the h-index (Hirsch index), calculated based on internationally recognized publications and citations from a third-party database, and the requirement to document measurable scientific achievements was not welcome by the scientific community. MNiSW started **publishing all job offers from the science sector online**, thus promoting researcher mobility. The legislation established also **the Council of Young Researchers**, as well as **the Science Ethics Committee**. Researchers can only be employed by PHEIs and PROs after open competitions, and undergo periodic assessments. The legislation restricts multi-jobbing – previously being a common problem in public R&D institutions, which was reducing the commitment of researchers and lowering the scientific outputs.

Committee for Evaluation of Scientific Research Institutions (KEJN) with nominees from science and industry is expected to **regularly evaluate all research institutions**, using measurable criteria including bibliometrics, and the results will influence the level of institutional funding (while institutions with the lowest ranks will not benefit from the government-distributed institutional funding). **The rules for KEJN evaluations** were announced in early 2013, and the first evaluation started soon afterwards. In 2012, the Ministry carried out **first competitions for the so-called KNOWs** – top academic institutions in specific research fields, with attractive financial awards. In parallel to the research evaluation, studies at public and private HEIs undergo **obligatory accreditation processes by the Polish Accreditation Committee (PKA)**. Universities were obliged to introduce **internal teaching quality assurance systems** and adjust their curricula to **the National Qualification Framework**. The reform introduced a broad autonomy of universities with respect to teaching contents, departing from the previous, detailed prescriptions regarding study programmes, with specific courses and even minimum numbers of teaching hours. **HEIs can introduce original study programs with well-defined and measurable learning outcomes**, while PKA manages the accreditation processes. The best study programs are financially rewarded in a competition run by MNiSW. The changes of HEIs are regarded as an important step towards the implementation of the Bologna process in Poland.

In 2011, MNiSW launched **the support program for research infrastructure**, financing new R&D infrastructure through a nation-wide competition. Other programs funded from MNiSW budget concerned: **support for ordered study** specialties (offered by universities to address

industry needs), **Diamond Grant** (funding program for the youngest researchers), **Top 500 Innovators** (training program for young innovative scientists, involving study visits to the leading technology commercialisation centres in the U.S.), **the National Program for the Development of Humanities** (sponsoring large research projects in humanities), and the so-called **PLUS programs** (supporting patenting, international co-operation and mobility at HEIs and PROs).

Two funding instruments by NCBiR and PARP adopted novel approach to the evaluation of proposals, supplementing written proposals by presentations by researchers or entrepreneurs in front of a selection committee, resembling selection of VC investments.

In November 2012, the Minister of Science and Higher Education announced plans for further changes in the R&I system:

- introduction of **less strict public procurement rules for PROs and PHEIs** (purchases of highly specialist scientific equipment are subject to the standard public procurement procedures, even though the European laws offer member state legislators more flexibility),
- ability to use **1% tax write-offs by corporations to subsidise scientific institutions**,
- **online availability of the outcomes of research financed from public sources**,
- plans to establish **a state-owned company "Polskie Innowacje S.A."** (Polish Innovations), acting as a sovereign fund co-financing innovative technologies developed by Polish researchers.

On February the 13th, 2013, the Minister of Science and Higher Education summoned rectors of PHEIs and presidents of the largest technology companies to the "Innovation Round Table". The discussion concerned among others the upcoming introduction of the above-mentioned tax write-offs, promoting science-industry co-operation, as well as the Minister's legislative proposal, intended to **empower scientists by assigning the ownership of inventions to the inventors working at PHEIs**.

The Ministry of Treasure and Bank Gospodarstwa Krajowego established in December 2012 **a state-owned company "Polskie Inwestycje Rozwojowe S.A."** (PIR, Polish Development Investments). PIR is intended to operate as a **sovereign investment fund**, supporting investment projects, important for the country's economic development, and the future investment targets are likely to include among others innovative ventures.

2.4 Recent policy documents

In May 2012, Ministry of Economy published the final draft of the ***Strategy for the Innovation and Efficiency of the Economy for the years 2012-2020 "Dynamic Poland"*** (**SIEG**) (RM, 2013). In the following months, the document was not subject to policy debates or approvals, and still maintains its draft status. SIEG encompasses the entire R&I policy spectrum, and is superior to other relevant plans and policy documents (including documents prepared by the Ministry of Science and Higher Education). SIEG sets quantifiable objectives, related to R&I funding and outputs in the national system of innovations. It also delegates specific tasks to

other governmental institutions. The R&I priorities, defined by SIEG, are discussed in the sub-chapter 4.1. In January 2013, SIEG was adopted by the Council of Ministers.

In August 2011, the Council of Ministers issued the ***National Research Program. Foundations for the science and technology policy and innovation policy of the state*** (**KPB**) (RM, 2011), complementing SIEG. The program defines preferable directions of research, taking into account the long-term needs of the economy, existing scientific and technological competencies and business potential. KPB is based on a similar document, adopted earlier by MNiSW. It is general in nature and refers to rather comprehensive research fields, so it cannot be regarded as a genuine source of prioritization of R&I investments (comp. discussion in sub-chapter 4.1). KPB is supposed to offer guidance to the Council of NCBiR, as both operating agencies are expected to define their strategic research programs.

In "*National Reform Programme Europe 2020*", prepared in April 2011 and submitted to the European Commission, the government committed to prepare also Enterprise Development Programme (Republic of Poland, 2011: 32), and to substantially amend the Industrial Property Law Act (Republic of Poland, 2011: 33) to support "establishment of a more effective legal and institutional system for industrial property protection […] increasing the knowledge and raising awareness of entrepreneurs on state-of-the-art methods to protect IP" (Republic of Poland, 2011: 32). Both activities were assigned to the Ministry of Economy, but as of December 2012, none of them was implemented (the draft Enterprise Development Programme was passed for public consultations in January 2013).

In November 2012, Ministry of Science and Higher Education published proposal for modifications of the science financing bill. The following proposed amendments are intended to streamline the management practices in the science sector:

- the Polish Roadmap of Research Infrastructure (PMDIB) will be regularly updated by the Minister based on applications for large research infrastructure investments from research institutions,
- funding for the popularization of science will be available only to scientific foundations and societies, continuously engaged in relevant activities,
- broader reliance on funding allocation algorithms using quantitative data instead of decisions of individual reviewers or collectives,
- integration of ICT systems collecting data on scientific institutions, research projects and researchers, with the purpose of improving access to the data for policy makers, as well as supporting open access to publicly funded research results, in line with *the Commission Recommendation f 17 July 2012 on access to and preservation of scientific information* (*2012/417/UE*).

2.5 Research and innovation system changes

MNiSW implemented a wide-reaching institutional reform of science and higher education, enacted in 2010-2011. Public research performers receive additional motivation to engage in applied research and transfer the research results to industry. PROs gained a new role in the system, with the focus on commercially useful research and encouragement to nurture co-

operation with business companies. PHEIs are subject to regular evaluations, related to research excellence and quality of teaching, and are expected to establish special purpose companies, dealing with commercial transfers of university technologies. Committee for Evaluation of Scientific Research Institutions (KEJN) will perform regular evaluations of PROs and PHEIs, and the evaluation results will define the levels of institutional funding. The visible linkage between performance and availability of funding became the defining characteristic of the recent institutional changes. The above-discussed reforms strengthened the positions of NCN and NCBiR, the government's main R&D funding agencies. Both Centres enjoy high degrees of autonomy, and their boards involve representatives of academia and private sector. NCBiR became the main source of R&I directions in Poland, funding applied research projects through multiple new, focused initiatives. It demonstrated responsiveness to new research trends while defining new program themes, and set new standards in project evaluations by involvement of not only scientists, but also technology transfer specialists.

2.6 Regional and/or National Research and Innovation Strategies on Smart Specialisation (RIS3)

Since the accession to the EU, Polish policy makers gained access to disproportionally high levels of funding, which could be used for support of R&I. The availability of funding induced the needs for expert guidance on preferable spending directions. In the first years of Poland's EU membership, groups of experts carried out altogether about 40 technology foresight on the national, regional and industry levels, and many were financed from the EU Structural Funds. In 2010, MNiSW commissioned a formal evaluation of the foresights. The analyses offered conflicting recommendations, some motivated by interests of specific stakeholders, which reduced their value. Major benefits of these foresight exercises were: increased interests of science and technology experts in R&D planning, awareness of recent technological trends in the global environment, and co-operation among various stakeholders on regional or industry levels. In October 2008, the most ambitious of these efforts – National Foresight Program Poland 2020 – concluded with a list of 114 macro-themes and 680 detailed R&D themes, recommended for public support. The substantial numbers of possible specializations reflect the lack of focus and difficulties in prioritization, when the broad roster of experts defines recommendations, at the same time representing interests of own employing organizations. In 2010, MNiSW launched a multi-annual project "*National Foresight Program – implementation of results*", focused on the creation of R&D roadmaps and monitoring system, and commissioned the works to a consortium, led by the Central Mining Institute.

In parallel, the Ministry of Economy was carrying out its own project "*Technological Foresight of Industry – InSight 2030*" (www.fortech2030.pl), which yielded a final report with an extensive set of recommendations in December 2011. The proposed priorities for the Polish industry for the timeframe up to 2030 were concentrated around 35 competitive industrial specialties, aggregated into 10 research areas (MG, 2011: 11):

- Industrial biotechnology
- Nanotechnology
- Advanced production systems

- Information technologies and telecommunication
- Microelectronics
- Photonics
- Development of clean carbon technologies
- Rationalization of energy utilization
- Modern appliances for primary industry
- Innovative technologies of obtaining raw materials

The industrial foresight identified 127 key technologies, which were expected to increase the competitiveness and innovativeness of Polish industrial companies.

The above-described foresight efforts did not actually reduce the uncertainty surrounding R&D priorities of the government. In 2011, the Council of Ministers adopted the National Research Program (comp. sub-chapter 4.1), listing a broad range of R&D areas, not necessarily related to the outcomes of the earlier foresight studies. In 2012, a representative of the Ministry of Economy, questioned by the Commission on Innovativeness and New Technologies of the Polish Sejm (lower house of the parliament) pointed to the excessive number and scattering of technological areas, recommended in foresight projects, and the need to select a smaller number of priority areas (Sejm, 2012: 5). It is worth to note, that the statement was uttered in September 2012 – several months after the same Ministry of Economy published the final draft of its Strategy for the Innovation and Efficiency of the Economy (comp. sub-chapter 4.1), and over a year after the adoption of the National Research Program. Government institutions understand the need for identifying and selecting smart specializations of regions and of the national economy, but little prioritization can be observed in the contents of strategic plans, and R&D performers can only infer the priorities by observing the focus of funding instruments by NCBiR, MNiSW and PARP. The government confirmed in "National Reform Programme Europe 2020", submitted to the European Commission in April 2011, that "in a longer perspective, it would also be necessary to specify the so-called smart specialization plans for the country and for the regions" (Republic of Poland, 2011: 30), but these plans have not yet been adequately prepared and implemented. In 2013, the public and local administration institutions are determined to achieve substantial progress with RIS3, due to the planning efforts for the new operational programmes 2014-2020.

Poland is divided into 16 regions (voivodeships), and for the years 2007-2013, 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 government website: http://www.funduszeeuropejskie.gov.pl/RPO/Aktualnosci/Strony/default.aspx. The planning efforts for the new financial perspective 2014-2020 involve a stricter delineation between national and regional support measures, and the discussions point toward the future regional focus on supporting the absorption of innovations, while the R&D support would be managed by the government agencies. Several years ago, all 16 regions prepared and formally adopted Regional Innovation Strategies. List of regional policy documents with updated web links is available at http://www.rim-europa.eu/index.cfm?q=p.baseline&r=PL.

These documents are being updated in line with the RIS3 framework, reflecting the smart specialization of regions. In most regions, these efforts have not yet yielded demonstrable results, with the exception of four regions: Greater Poland (UMWW, 2010a; UMWW, 2010b), Lower Silesia (ZWD, 2011), Silesia (SWŚ, 2011) and Western Pomerania (ZWZ, 2011). The Silesian voivodeship prepared also a dedicated technology development program, based on the Regional Innovation Strategy and more detailed analysis of R&D potential of the region (ZWŚ, 2011). Unfortunately, most of these planning efforts did not really support focus on specific technology areas or regional specialities, as the regions selected similar specialisations, related to the most popular, broadly defined technology areas, without major intra-regional differentiation.

2.7 Evaluations, consultations

Since 2004, Polish government agencies have distributed a substantial amount of EU Structural Funds, used among others to support R&D efforts. Poland belongs to EU leaders in this respect, with efficient fund distribution mechanisms and controlling functions. The government commissioned *ex ante* and mid-term evaluations of the Operational Program Innovative Economy (POIG), including evaluation of consistency between POIG 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 programs (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). Important findings from the evaluation studies include: lack of systemic approach due to the existence of separate financial instruments for R&D facilities and R&D projects, problems related to the periodic character of funding with uncertainty of continuation, lowering motivation of R&D performers, and bureaucratic obstacles encountered by beneficiaries (PAG Uniconsult, 2011: 9). Between 2007 and 2012, altogether exactly 700 evaluation studies were carried out with reference to the EU Structural Funds (including small-scale analyses and on-going evaluation efforts of funding institutions), and the database listing all the projects and hyperlinks to source materials is regularly updated on the government website www.ewaluacja.gov.pl/WYNIKI/Strony/Wyniki_badan.aspx. English-language summary of evaluations related to support measures for R&I, based on the EU Structural Funds, was published by PARP in: Pokorski (2011). PARP regularly evaluates its support measures, and the information about evaluation projects from 2012 is available online at http://badania.parp.gov.pl/index/more/31068. R&D funding agencies NCN and NCBiR adopted a similar approach, conducting *ex ante* evaluations before introducing new financial support instruments, and regularly reviewing results of interventions, but the evaluation reports are not publicly available. NCBiR published evaluation results on its website http://www.ncbr.gov.pl/o-centrum/ewaluacja/ewaluacja-2012/ and announced plans for 15 evaluations in 2013. NCN conducted an extensive survey among the applicants of NCN's first grant competitions (http://ncn.gov.pl/sites/default/files/pliki/statystyki/ncn_prezentacja_badania_ankietowe_wsrod_wnioskodawcow.pdf) and used the findings to improve the programs. MNiSW also resorted to evaluative techniques to draw conclusions from multiple science and technology foresight studies, conducted by specific regions and industries. Ministry of Economy is also using evaluations to modify innovation policy instruments – a recent example was the amendment of

legislation concerning tax incentives for companies acquiring new technologies, resulting from the observed limited interests in the support instrument. The Ministry 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 program 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 the detailed requirements, often larger enterprises, resorting to the help of specialist consulting companies (Kapil et al., 2012: 40). Supreme Audit Office (NIK) conducted in 2012 a comprehensive audit of science funding, which indicated that in spite of the increases in research budgets, no significant increases in science outputs could be observed (in terms of publications in highly ranked journals, patents and implementations of research results) (NIK, 2012: 8). According to the audit, some PHEIs and PROs incorrectly document implementations of research results (NIK, 2012: 21), and NCBiR does not apply sufficiently strict criteria when evaluating projects, accepting misleading declarations from funded organizations, and signing acceptance protocols in spite of missing deliverables (NIK, 2012: 41-43). Ministry of Regional Development scheduled for 2013 *ex ante* evaluation of the planned Operational Program Smart Development, which will be the major mechanism for distribution of the EU Structural Funds in 2014-2020. Nevertheless, no holistic evaluation of the innovation policy in Poland has been performed in the recent years.

2.8 Policy developments related to Council Country Specific Recommendations

The Council of the European Union adopted in July 2012 Country Specific Recommendations (CSR), relevant for R&I policy in Poland. The Council noted that the national target of 1.7% GERD to GDP in 2020 is very ambitious and the country is not on-track to meet it. It also urged Poland to: (1) improve linkages between R&D performers and industry, (2) establish "priority areas and instruments supporting the whole innovation cycle", and (3) offer guarantees and bridge financing to improve access to finance for R&I initiatives.

The recent changes in the R&I system in Poland are clearly directed at addressing the above-listed challenges, but their effectiveness is not clear yet. Recommendation (1) refers to the dominant theme of the recent science and higher education reform – PROs and PHEIs are motivated to engage in co-operative projects with industry, their institutional evaluation depends among others on measurable achievements in the area of technology transfer, and numerous R&D funding instruments require the formation of consortia, involving academic and business organizations. In particular, programs offered by NCBiR induce industry and academia co-operation and are successful in motivating companies to invest in scientific projects – in 2011, €88.1m and in 2012, €306.3m were spent by business enterprises due to their commitments in NCBiR-funded projects (MNiSW, 2013: 5).

CSR (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 has multiplicity of dedicated support instruments, but the instruments are offered by several different government agencies and some participants of the national system of innovations might not notice their synergies and complementarities. Nevertheless, the portfolio of instruments is comprehensive and covers most elements of the innovation cycle, and in 2012, 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). More problematic is the prioritization, as government-defined priority areas for R&I are very broad and thus do not facilitate decisions of R&D performers and investors. New policy documents, National Research Program (KPB), Strategy for the Innovation and Efficiency of the Economy (SIEG) and Enterprise Development Program (PRP), aim at streamlining and prioritizing the support measures and will be used as the basis for programming RDI support in years 2014-2020.

Recommendation (3) was enacted by the government with dedicated support instruments that finance the participation of Polish applicants in international projects, including FP7. The state-owned bank BGK offers credits, supporting technology projects, and it recently has intensified these operations thanks to the amendments of relevant laws. SMEs can benefit from publicly funded loans and credit guarantees, particularly focusing on innovation-related investments, and their distribution is offered within the National Service System for Small and Medium-Sized Enterprises (KSU), co-ordinated by PARP. BGK's venture capital arm, KFK, invests in private VC funds, covering up to 50% of capital, available to applicant companies. As of early 2013, KFK was involved in 14 VC funds, supporting among others innovative ventures. Start-ups can in turn benefit from seed capital, distributed by specialist investment companies based on the EU Structural Funds (support measure POIG 3.1). Among the recently announced initiatives, NCBiR prepared a program called "BRIdge VC", intended to orchestrate public and private funds for the support of R&I projects, which require bridge financing or could benefit from venture capital.

3 STRUCTURAL CHALLENGES FACING THE NATIONAL SYSTEM

Table 2. Innovation Union Scoreboard indicators for Poland (data for 2010).

HUMAN RESOURCES	
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	0.50
Percentage population aged 30-34 having completed tertiary education	36.9
Open, excellent and attractive research systems	
International scientific co-publications per million population	213
Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	3.52
Finance and support	
R&D expenditure in the public sector as % of GDP	0.53
FIRM ACTIVITIES	
R&D expenditure in the business sector as % of GDP	0.23
Linkages & entrepreneurship	
Public-private co-publications per million population	5.30
Intellectual assets	
PCT patents applications per billion GDP (in PPS€)	0.45
PCT patents applications in societal challenges per billion GDP (in PPS€) (climate change mitigation; health)	0.12
OUTPUTS	
Economic effects	
Contribution of medium and high-tech product exports to trade balance	0.88
Knowledge-intensive services exports as % total service exports	26.14
License and patent revenues from abroad as % of GDP	0.05

Data Source: Innovation Union Scoreboard 2013

Poland's RDI system experienced significant changes in the recent years, and key R&D indicators are constantly improving. The country transforms the science and higher education systems, focusing on quantifiable effects of R&D and increasing the importance of competition-based funding for R&D.

GERD as percentage of GDP remains low in comparison with EU-27 average and targets for Poland – it was 0.68% in 2009, 0.74% in 2010 and 0.77% in 2011. Nevertheless, the country improved the size of its relative R&D investments, which in 2006 accounted only for 0.56% of GDP, and the observed increase is substantial. Between 2007 and 2011, the average annual growth of Polish GERD was 12.6%, and **Poland's growth in GERD was the fourth**

strongest in the EU (GUS, 2013a: 51). GOVERD at 0.26% of GDP was not very distant from the EU average of 0.26%, but HERD of 0.27% of GDP was relatively low (EU-27: 0.49%), and BERD even lower as 0.23% of GDP (EU-27: 1.26%) (Eurostat 2012). If absolute values of R&D expenditures are analysed, the amount of funds allocated to R&D in Poland stands out in comparison to many other EU countries. Poland's GOVERD expressed in Euro (€) was in 2011 the 7th largest in the EU (after Germany, France, Spain, UK, Italy and Netherlands) (Eurostat, 2012). Unfortunately, the substantial government expenditure does not seem to stimulate corresponding increases in business investments in R&D. Even more funds on R&D are spent in Poland from EU's Structural Funds than from the national civil R&D budget (EC DGRI 2011: 255), and thanks to the availability of the EU funds, the government spends a relatively small share of its total budget on R&D – GBAORD in 2009 was only 0.76% of total government expenditures, compared with EU-27 average of 1.53% (Eurostat, 2012) (no data available for 2010 or 2011).

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. Scientists working for PHEIs and PROs are well-organised in powerful associations, receiving media attention, and introductions of the recent reforms were preceded by consultations, resembling negotiations with labour unions. In consequence, some initially planned measures were modified in order to satisfy public requirements, thus diminishing their actual effectiveness. Various studies concerning R&D performers in Poland indicate that limited interests in innovations or applied research might also be linked to attitudes and perceptions, resulting from cultural and historical factors, and governmental institutions were trying to address these problems by awareness campaigns.

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

Key challenge 1: Low levels of business investment in R&D and in-house technological innovation

The primary challenge for the RDI system in Poland is stimulation of business expenditures on R&D and in-house technological innovations in business enterprises. Expenditures of business enterprises accounted in 2011 for 30.13% of GERD, while the EU's average was 62.34%, and other countries from the Central and Eastern Europe had higher BERD/GERD ratios (from ~30% to 58%) (Eurostat, 2012). Polish BERD was low at 0.23% of GDP (EU-27: 1.26%) (Eurostat, 2012). Also, a very low percentage of funds allocated by the Polish government as state aid is granted to cover costs of R&D (EC DGRI, 2011: 340). Companies prefer to spend more on non-R&D related innovations: 1.25% of their turnover, with EU's average of 0.71% (PRO INNO Europe, 2012: 63). Poland's share of venture capital in GDP is only 0.034% (EU-27: 0.095%) (PRO INNO Europe, 2012: 63), but the percentage of GDP generated by public procurement was inversely high at 8.20% (EU-27: 3.60%) (EC DGRI, 2011: 366).

Instead of domestic generation of innovations, Poland resorts to imports and among the large EU member states, it maintains the highest share of GERD allocated to royalties and licence fees paid to foreign suppliers, as over 50% of domestic expenditures on R&D cover transactions in foreign knowledge products (EC DGRI, 2011: 403). Future increases in Poland's GERD might primarily benefit foreign technology suppliers, not national RDI sector, unless more targeted measures are introduced. The high domestic demand for new technologies and absorptive capacity collide with the much weaker potential for local knowledge production. The government expenditure on R&D seems to have a crowding out effect, not stimulating the expected increases in BERD. Nevertheless, the absolute BERD at €854.6m in 2011 was higher than in other new EU member states, with the exception of the Czech Republic, while still significantly lower than the BERD of most of the old EU members (Eurostat, 2012).

In 2011, 1,647 business enterprises declared expenditures on R&D (GUS, 2013b), and only 430 registered purchases of research equipment, classified as fixed assets (GUS, 2013b). Among economy sectors investing in R&D in 2011, manufacturing accounted for 50.5%, and information and communication sector for 26.3% of total business spending, while agriculture, construction, finance and insurance had only minor importance (GUS, 2013b). Similarly, the R&D personnel in business enterprises concentrates in the manufacturing sector (50.9%) and the information and communication industry (32.8%) (GUS, 2013b). Some sectors, which were key to the Poland's economic growth in the recent years, have only limited R&D investments and relevant employment.

66.0% of business expenditures on R&D were in 2011 spent by large enterprises, employing 250 or more persons, while medium enterprises (50-249 employees) accounted for 20.3%, small enterprises (10-49 employees) – for 9.8% and micro-enterprises (up to 9 employees) –3.7% (GUS, 2013b). Spending of SMEs on R&D remain alarmingly low in comparison with other EU countries – in 2008, BERD by SMEs corresponded to 0.07% of GDP in Poland, while the corresponding average for the EU-27 was 0.25% (EC DGRI, 2011: 326). Alarming are the low shares of SMEs innovating in-house (13.76%; EU: 30.31%), introducing product or process innovations (17.55%; EU: 34.18%) and collaborating with other organisations (6.40%; EU: 11.16%) (PRO INNO Europe, 2012: 63). One should however remember that many micro-enterprises in Poland are one-person companies, established by individuals seeking to optimize the social insurance, health insurance and tax rates and signing subcontracting agreements instead of employment contracts. Regional distribution of BERD presents additional problems as 34.4% of all business enterprise expenditures on R&D in Poland are spent in Masovia (mainly Warsaw) (GUS, 2013b).

With reference to BERD, the World Bank expressed the suspicion that Polish enterprises tend to under-report their R&D expenditures and the scope of innovative activities (Kapil et al., 2012: 9). This is an important remark, as the existing R&D reporting mechanisms are burdensome for enterprises, and not integrated with standard financial and fiscal reporting. Some R&D performers have never reported any relevant expenditures, and 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 dynamic development of Poland's economy and changes to the total factor productivity suggest that the official government data on BERD might be under-estimated, and the proposition was supported by the World Bank experts (Kapil et al., 2012: 9). In addition, the suspicion is compliant with empirical

evidence of significant increases in R&D expenditures of selected business sectors, e.g. BERD of the Poland's ICT sector increased by 14% between 2010 and 2011 according to the most representative, national survey of ICT companies in Poland, conducted annually by the specialist magazine Computerworld (Czerniejewski, 2012).

While the counts of patent applications in Poland are limited, in 2011 only 34.4% of them were submitted by business enterprises (GUS, 2012b: 423). Sales of innovative products (both new-to-market and new-to-firm) corresponded to 9.84% of Polish business enterprises, while the EU-27 average was 13.26% (PRO INNO Europe, 2012: 63). In manufacturing sector, 5.4% of sold production can be classified as high technology and 27.0% – as medium-high technology (GUS, 2013b). People working for high technology companies corresponded in 2011 to 4.9% of total employment in manufacturing, and employees of medium-high technology firms were 20.9% of all employed in the sector (GUS, 2013b). Employees of high-tech manufacturing account for 0.08% of total employment (EU: 1.1%), and medium-high tech manufacturing – 4.1% (EU: 4.6%) (EC DGRI, 2011: 398). In service sector, knowledge-intensive services account for 34.3% of total sales volumes (GUS, 2013b). However, employment in services as the share of total employment (55.9%) is lower than for the EU-27 (70.5%) (EC DGRI, 2011: 390), thus driving down the share of employment in knowledge-intensive services in total employment – Poland: 29.5%, EU: 38.1% (EC DGRI, 2011: 398). Poland's 2011 share of high-tech export in total export was 5.2%, compared with 15.4% for EU-27 (GUS, 2013a: 129). Licence and patent revenues from abroad were 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 at 33.05% remain lower than for EU-27 (48.13%) (PRO INNO Europe, 2012: 63).

In 2010, only 33 companies used tax exemptions for acquisition of new technologies, with an average exemption of €237k (MF, 2011: 17), and after amending the relevant legislation, in 2011 the number of beneficiaries went up to 97, and average exemption increased to €678k (MF, 2012: 17). The data demonstrate very low interests in the key fiscal instrument, intended to support innovations in business sector – only 97 out of 349,967 corporate tax payers (MF, 2012: 5) used the exemptions in question. Between 2008 and 2010, 6 enterprises lost the status of R&D centre, associated with additional fiscal incentives, and in 2011, there were only 19 companies with the registered R&D centre status (MG, 2012: 6).

The data suggest that the majority of business enterprises in Poland look for sources of competitive advantage other than innovations. Government RDI policies of the recent years were constantly attempting to change the attitudes and behaviours, but they do not bear fruit in terms of the expected increases in BERD, numbers of innovative enterprises and innovative products. Many companies successfully operate as low cost subcontractors of Western partners, and are not motivated to innovate. Substantial public spending on R&D is not accompanied by parallel increases in business investments, and this cast doubts on the overall effectiveness of the public support system for RDI. In the background document, prepared for the Strategy for the Innovation and Efficiency of the Economy for the years 2012-2020, the Ministry of Economy suggested that "the existing system, intended to support innovativeness of enterprises, favours the purchases of ready-to-use solutions, thus supporting transfers of foreign solutions" (MG, 2012: 6), what might be considered as an important factor stifling the in-house innovativeness of the Polish business sector.

Key challenge 2: Limited synergies between the science and industry, restricting the innovative potential of the economy

Total R&D expenditures in 2011 were distributed among basic research (36.4%), applied research (23.9%) and experimental development (39.7%) (GUS, 2012b: 416), while the business sector allocated 69.5% of its expenditures on experimental development, 21.6% on applied research and 8.9% on basic research (GUS, 2012b: 416). This imbalance could stimulate the co-operation between the science and industry companies, but the observed outcomes are disappointing.

The number of research projects carried out by PHEIs and PROs, contracted by the industry, remains low, numbers of joint patent applications are insignificant and only 2.5 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 36.2 for the EU-27 (PRO INNO Europe, 2012: 63). Between 2000 and 2009, only 0.5% of scientific publications from the University of Warsaw were co-authored with business, and the ratio for the Jagiellonian University in Cracow was even lower at 0.2% (Klincewicz, 2012).

Business enterprises in 2011 funded only 2.7% of R&D costs at PHEIs, and 8.0% at PROs, while the largest PRO, Polish Academy of Sciences, benefited only from 1.4% of business contributions to its R&D budget (GUS, 2013b). Among PHEIs, business organizations funded in 2011 1.2% of R&D at universities, 4.7% at technical universities, 4.3% at agricultural universities, and 0.4% at medical universities (GUS, 2013b).

Business enterprises in Poland employed in total 657 scientists, holding PhDs or academic titles, out of the total population of 70,290 employed scientists with these qualifications (GUS, 2012b: 412). In 2011, altogether only 17.8% of all researchers in Poland were employed by business enterprises (GUS, 2012b: 412), and the share was significantly lower than the 2008 estimate for the entire EU: 45.8% (EC DGRI, 2012: 115).

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

Investors and R&D performers find it difficult to identify clear priorities in the government's RDI support policies. Even though the planning documents declare strategic areas in terms of fields of research or technology types, the directions are very general and so broadly distributed, that it is hard to actually regard them as priorities. R&D performers could benefit from a clear and consistent focus of the government, coupled with increased financial support for these key areas. The process is distorted by the legal requirements to reach consensus with the scientific community about the intended priorities, and in the recent years, such consultations derailed some initially ambitious plans for funding reforms. Outcomes of government-funded, large-scale technology foresight efforts were not transformed into specific, measurable objectives for the RDI system.

Intramural R&D expenditures of business enterprises in 2011 were mostly allocated to engineering and science research (GUS, 2013b), and the field accounts for the largest share of the R&D personnel (37.9% in total, 79.6% of R&D personnel in business enterprises) (GUS,

2012a: 263). Among engineering and technical sciences, most funds were spent on the domains of electrical, electronic, information, mechanical and materials engineering (GUS, 2012a: 54). Contradictory to the focus of business enterprises and composition of R&D personnel, Polish students (including doctoral students) tend to prefer social sciences and humanities. Table 3 presents a comparison of the importance of diverse science fields.

Table 3. Relative importance of fields of science in Poland.

	Engineering and science (excluding natural sciences)	Natural sciences	Medical and health sciences	Agricultural sciences	Social sciences	Humanities
Intramural R&D expenditures, 2010	47.0%	24.7%	10.3%	7.7%	6.2%	4.2%
Intramural R&D expenditures of business enterprises, 2010	74.7%	13.0%	8.2%	2.3%	1.0%	0.8%
Employment in R&D, 2010	37.9%	19.3%	13.4%	6.6%	12.3%	10.4%
Employment in R&D in business enterprises, 2010	79.6%	11.5%	5.4%	2.2%	0.8%	0.5%
Public funding for R&D projects, 2012	73.2%	6.7%	10.1%	2.7%	3.7%	3.6%
Doctoral candidates, 2010	17.6%	15.5%	9.4%	4.8%	20.22%	32.41%

Data source: GUS (2012a: 54-55, 305), MNiSW (2013: 46).

Polish scientists had the highest absolute counts of publications in 2011 in the areas of medicine, physics and astronomy, biochemistry, genetics and molecular biology, chemistry and engineering (SCImago, 2012). When citations to publications from 1996-2011 are concerned, the most important research areas are: chemistry, decision sciences, earth and planetary sciences, materials science, mathematics, pharmacology, toxicology and pharmaceutics, as well as physics and astronomy (SCImago, 2012).

Public funding, distributed by NCN in 2011-2012, was mainly used to fund projects in Science & Technology and medical sciences, but the distribution among fields of research was based on a bottom-up approach and depended on the submitted project proposals. Funds for applied research, distributed by NCBiR, are in turn allocated in multiple programs, including targeted interventions, stimulating research in selected areas, such as: aviation, ICT, nuclear energy, shale gas, graphene-related research, environmental technologies. There seems however to be no

consistency in funding and support directions, and the bottom-up approach resembles more 'trial-and-error' than outcomes of strategic decisions, based on a thorough analyses of R&D potential and aspirations.

Analysis of sales data indicates that the most important types of Poland's high technology products are: computers, electronic products and optical instruments, while among the medium-high technology products, chemicals, electrical equipment, other machinery and equipment and motor vehicles dominate (GUS, 2012a: 319). Poland's high-tech exports consisted in 2011 of: computers and office machinery (35.9%), electronics and telecommunications (29.4%), aerospace (13.1%) and scientific instruments (10.1%) (GUS, 2013b). The EU Structural Funds for business enterprises, distributed by PARP and NCBiR, were not earmarked for specific technology types (with the exception of dedicated instruments for ICT-related projects) and thus do not encourage the pursuit of technological specializations.

Without the necessary focus of efforts and financial resources on specific, well-defined science and technology areas, participants of the innovation system do not understand the RDI priorities of the government. In many cases, the lack of government commitments and related uncertainty discourage the R&D performers from investments and in-house development. Specific RDI priorities need to be formulated and shared, as the clarity would support the orchestration of other necessary resources (finance and people).

Key challenge 4: Increasing internationalization and attractiveness of RDI system

Polish companies are avid users of foreign technologies – over 50% of GERD covers the purchases of foreign products and services (EC DGRI, 2011: 403). Statistics concerning formal transfers of technologies to industrial enterprises in 2011 document the conclusion of 712 inward licensing agreements, 327 joint R&D projects, 709 acquisitions of means automation (e.g. manufacturing lines) and 510 technical consulting service projects, with technologies supplied mostly by entities from other EU countries (GUS, 2013a: 140). 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 also 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 in 1996-2011 was 29.18% (SCImago, 2012). 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. In 2009, Poland had 186 scientific publications with international co-authors per one million population – a ratio significantly lower than the EU-27 average of 491 (EC DGRI, 2011: 186) and one of the lowest among all EU countries. At the same time, the average cost of a scientific publication authored by Polish researchers is relatively lower than for publications originating in other EU countries, outlining the cost advantage of Poland's research system. Recent science and higher education reforms, intended to stimulate the internationalization of scientific publications, were subject to a fierce criticism by scientists, dissatisfied with the requirements to publish in highly ranked English-language journals, use citation-based indicators from international databases or prepare grant proposals in English so that they could be evaluated by foreign experts.

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, 2012: 188). It should be emphasized that Polish researchers and inventors have limited ties to the US organisations, compared with their counterparts from other countries. Poland has the lowest participation in FP7 per 1,000 researchers (in FTE) among all EU-27 states (EC DGRI, 2011: 261).

As of March 2011, Poland ranked 11th in terms of the number of applicants to FP7 in the EU (2.53% of EU), with only 327 SMEs submitting proposals (EC DGRI, 2011: 190), and top foreign collaborators for Polish researchers coming from Germany, the UK and Italy (EC DGRI, 2011: 190). By the end of October 2012, altogether 1,627 projects involving Polish researchers were funded in FP7 (MNiSW, 2013: 59), and only in 184 projects Polish institutions acted as projects coordinators (MNiSW, 2013: 60). 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.

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.

Key challenge 5: Inducing knowledge spill-overs from foreign direct investments

In 2011, 45.4% of R&D investments in business sector were generated by enterprises controlled by foreign capital (GUS, 2013b) and the country's major R&D initiatives are funded by the EU Structural Funds. Altogether 442 entities (including 162 business enterprises) benefited in 2010 from foreign funds supporting R&D, with majority of external funds coming from the European Commission (GUS, 2012a: 194). Enterprises with foreign ownership are more technologically

advanced - 10.5% of their sold production can be classified as high-tech, and 37.9% – as medium-high tech, compared with 6.8% and 27.2% for the total population of manufacturing enterprises in Poland (GUS, 2012a: 318). Poland experiences a constant influx of foreign direct investments, being one of the most attractive FDI locations in EU. The country attracted foreign investments of €9,863m in 2009, €6,686m in 2010 and €10,904m in 2011 (PAIZ, 2012), with majority of FDIs originating in other EU countries (NBP, 2012). Preliminary data, published by the National Bank of Poland in early 2013, indicate a sharp drop in FDI volumes in 2012 to a level of 21% of investments from 2011. There are however substantial discrepancies between these early macroeconomic estimates and the data on individual new investments, collected by PAIZ.

Government agency supporting FDIs (PAIZ) was involved in large FDI projects in BPO, automotive, electronics and ICT sectors, with investors mostly from the US, Germany, UK, China and France (PAIZ, 2012). The character of the largest FDIs in Poland evolves towards knowledge-based activities, but the government activities focus on attracting foreign capital and creating new workplaces. 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). Less 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. Polish government does not use instruments such as local content requirements, or technical standards favouring local suppliers, and foreign investors benefit from public support without the need to commit to the establishment of RDI linkages or local R&D projects. Without appropriate measures, the economy might attract excessive number of foreign investments, motivated by low labour cost in Poland and manufacturing efficiencies, but do not benefit from foreign expertise in R&D and knowledge creation. Recently, even the interests in low cost labour are questioned due to the unclear future of the Special Economic Zones (SSE), selected geographical areas where investors can enjoy sizeable tax exemptions. Ministry of Finance opposes the extension of existing benefits, and the uncertainty negatively impacts new foreign investments. Regardless of the future of SSE, foreign investors setting up operations in Poland can still benefit from all the support measures, available within the Polish innovation system.

4 ASSESSMENT OF THE NATIONAL INNOVATION STRATEGY

4.1 National research and innovation priorities

In November 2009, the Council of Ministers decided to divide the future efforts related to the national development strategy into 9 strategic documents, including the ***Strategy for the Innovation and Efficiency of the Economy for the years 2012-2020 "Dynamic Poland"*** **(SIEG)** (RM, 2013). SIEG's draft was published in May 2012, after social and governmental consultations, and the final document was adopted by the Council of Ministers in January 2013. It is the most extensive strategic document setting R&I policy priorities, and adequately reflects the efforts of public administration. The development of the strategy was coordinated by the Ministry of Economy, and the document is superior to other relevant policy documents.

SIEG contains four broad objectives, which are further decomposed into more specific actions (RM, 2013: 9):

- Objective 1. Strengthening regulatory and financial environments to address the needs of an innovative and efficient economy – involves appropriate regulatory actions, shaping the macroeconomic environment, increase of expenditures on development and innovations, making the tax system simpler and more transparent, and increasing the availability of capital for innovative enterprises (including venture capital).
- Objective 2. Stimulating innovativeness through the increase in effectiveness of knowledge and work – by improving quality of research, tightening relations between science and industry, shaping pro-innovation culture, educating specialists for Science & Technology and developing Information and Communication Technologies.
- Objective 3. Improving the efficient use of natural resources and raw materials – with energy and resource efficiency, and sustainable construction practices.
- Objective 4. Increasing the internationalisation of the Polish economy – by supporting the exports and foreign investments of Polish companies, attracting foreign investors in Poland and carrying out international promotion of enterprises and the country.

Among specific actions, included in the Strategy, some deserve additional attention in the present report:

- Sub-objective 1.2.1. Increasing the public expenditures and stimulating private expenditures on R&D.
- Sub-objective 1.2.2. Adjusting the structure and increasing the effectiveness of public expenditures on RDI – including competitive funding of projects, avoidance of non-refundable support forms (with preference for loans and time-restricted investments, stimulating the inflow of entrepreneurial capital), and promotion of private-public partnerships (RM, 2013: 39-40).

- Sub-objective 1.2.3. Identification and support for the development of domains and technologies with the highest growth potential – supporting the concept of smart specialization and evidence-based policy (RM, 2013: 40).
- Sub-objective 1.3.4. Rationalization of fiscal measures stimulating RDI activities – with preference for simplicity of fiscal incentives, but without more specific explanations (RM, 2013: 44).
- Sub objective 1.4.5. Development of venture capital financing – with financial support from the government for VC investors (RM, 2013: 47-48).
- Sub-objective 2.1.2. Development of international scientific and educational co-operation – including support for Polish research teams in international programs and cross-border research consortia (RM, 2013: 55).
- Sub-objective 2.1.4. Development of infrastructure for research and knowledge transfer – including the initiatives from the Polish Roadmap of Research Infrastructure (PMDIB) (RM, 2013: 55).
- Sub-objective 2.2.1. Enhancing the integration between the entrepreneurship policy and the innovation/science and technology policy – with more public support for young, innovative firms than for mature industries (RM, 2013: 56-57).
- Sub-objective 2.2.4. Strengthening regional innovation policies – involving selective support based on the principles of intelligent specialization (RM, 2013: 57-58).
- Sub-objective 2.2.5. Reducing the information asymmetries in the economic policy and innovation activities, as well as the sectoral and regional effectiveness – with specific actions related to changes in information disclosure obligations, including reporting R&D spending as part of corporate financial statements, and dedicated RDI expenditure reporting rules for foreign companies operating in Poland (RM, 2013: 58).
- Sub-objective 2.3.1. Promoting the co-operation between companies and other partners in RDI – including dedicated grants for consortia not individual applicants (RM, 2013: 60).
- Sub-objective 2.3.2. Supporting the researcher mobility in science and economy sectors (RM, 2013: 60-61).
- Sub-objective 2.3.3. Supporting the co-operation within enterprise clusters (RM, 2013: 61).
- Sub-objective 2.3.4. Strengthening the potential of technology platforms in Poland (RM, 2013: 61).
- Sub-objective 2.3.5. Establishment of technology broker system – helping transfer and commercialize technologies, developed by academia or other companies (RM, 2013: 61).
- Sub-objective 2.4.1. Shaping the pro-innovation attitudes of entrepreneurs, particularly in the SME sector (RM, 2013: 62-63).
- Sub-objective 2.4.4. Creating the culture of innovative academic entrepreneurship (RM, 2013: 63-64).
- Sub-objective 2.4.5. Effective use of intellectual property rights, patent and scientific information – including relevant education and establishment of specialized intellectual property court (RM, 2013: 64).

- Sub-objective 3.1.3. Support for research and export potential in the field of environmental technologies, with particular focus on low-emission carbon technologies (RM, 2013: 73).
- Sub-objective 4.1.2. Financial support for exporting enterprises (RM, 2013: 78).
- Sub-objective 4.3.1. Focus of public administration and diplomacy on selected countries, regarded as priority markets (RM, 2013: 81).

SIEG's objectives are reflected in other policy documents. Most importantly, it puts emphasis on the role of innovativeness and R&D as sources of competitiveness of the national economy. It signals an important change in policies, as in the past, more important were infrastructure investments, necessary for the further economic development.

SIEG was criticized for its general character, inclusion of numerous directions for intervention without the needed specificity. It is a complex, textbook-like catalogue of all relevant measures, and successful implementation of all the prescribed changes might not be possible within the given timeframe. The top-level objectives and sub-objectives are often vague and not supplemented by specific action plans. Many of them are consistent with past declarations and administrative efforts, which so far have not yielded expected results, so the new strategic plan might be interpreted as "business as usual" scenario by many stakeholders, including government agencies. These perceptions might explain, why the social consultations of a strategic document of major importance for the future of a country's economy engaged in 2011 altogether 30 stakeholders, with only few business enterprises or their associations (RM, 2013: 102).

For each sub-objective, institutions in charge are indicated (ministry or central government body), and the problem owners are expected to adopt necessary legal and organizational measures to implement the delegated tasks. In many cases, one sub-objective has multiple institutions assigned, without clear division of responsibilities, thus complicating the future implementation. It is also not sure, if additional funding is going to be allocated to some of the activities, and many ambitious ideas are resource-consuming. Sub-objectives of SIEG are assigned to specific implementation periods: 2012-14, 2015-17, 2018-20. Many administrative efforts should be made up to 2014, but since SIEG was adopted in early 2013, the work could not have been initiated in 2012 and deadlines might not be met. The most costly activities are envisaged for years 2015-2020 and most likely financed from the EU Structural Funds – but the distribution of EU funds will be decided by the Ministry of Regional Development (MRR), and there is risk of overlapping analytical work and conflicting priorities. Some objectives are also excessively ambitious – e.g. dramatic increases in efficiency in the Polish public sector are beyond the intervention areas of SIEG and closer to wishful thinking than to structured, disciplined strategic planning.

SIEG contains quantitative indicators, used to set ambition levels and verify the strategic progress. The strategy sets the following levels of GERD to GDP ratio: 0.93% in 2015 and 1.70% in 2020 (RM, 2013: 89). BERD should amount to 0.33% GDP in 2015, and 0.80% in 2020 (RM, 2013: 89). The objectives seem overly optimistic due to the detachment of GERD-related objectives from other measures, used in the strategic plan. For other objectives, SIEG defines specific indicators, which are much less ambitious and not congruent with the expected, substantial increase in R&D spending. For example, 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, 2013: 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, 2013: 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, 2013: 89). The strategic indicators do not establish a truly interlinked structure and it is questionable if the expected GERD levels could actually be accomplished even if the other indicators develop in accordance with the strategic objectives.

In response to an early version of SIEG, presented for public consultations in 2011, a team of researchers and business executives prepared a report, emphasizing aspects overlooked in SIEG (Vistula, 2011). The report was very critical of government efforts, pointing to bureaucracy and administrative barriers for entrepreneurs. It indicated several areas disregarded by SIEG: an urgent need to increase the level of commercial aspirations of Polish entrepreneurs (with focus on innovations and participation in globalized markets), and possibilities of using private foreign funds (including VC and private equity), exploiting the potential of Polish emigrants in key technological markets, and using public procurement to order products and services from small, innovative firms in order to strengthen the national system of innovations. Ministry of Economy – the coordinator of SIEG – does not always have the best relations with local business enterprises, because of certain burdensome administrative regulations, controversial draft bills and initiatives (comp. e.g. previously discussed issue of unitary patents, when protests by major business associations in Poland were initially ignored by the Ministry). In spite of SIEG's importance as a high-level policy document, without closer involvement of business, the strategy is likely to remain detached from the reality and needs of business sector, and public consultations in 2012 demonstrated relative lack of interest of business community, which is likely to undermine SIEG implementation in the coming years.

The Council of Ministers adopted in August 2011 another key strategic document, the ***National Research Program. Foundations for the science and technology policy and innovation policy of the state*** **(KPB)** (RM, 2011). KPB defines long-term objectives, which are subsequently decomposed into more detailed strategic plans, prepared by the Council of NCBiR and NCN as their strategic research programs, with medium-term objectives and assigned funds. In the past, a document similar to KPB was adopted by MNiSW, but since 2011, the plan enjoys the high-level status and complements SIEG. KPB indicates priorities for R&D activities, addressing long-term needs of the national economy, existing scientific and technological potential, as well as possibilities of supporting the development of technology-based companies and of exploiting the available EU funding.

KPB indicates seven broad R&D priorities (RM, 2011: 6):

- new energy technologies
- lifestyle diseases, innovative drugs and regenerative medicine,
- advanced information and telecommunication technologies and mechatronics,
- advanced materials,
- natural environment, agriculture and forestry,
- social and economic development of Poland in the globalized markets,
- national security and defence.

The program includes descriptions of each priority, which nevertheless remain very broad and inclusive. For example, new energy technologies include nuclear energy, use of hydrogen, clean coal technologies, renewable energy sources, technologies for exploitation of rare earth metals and fossil fuels exploration (RM, 2011: 10-11), and advanced materials encompass nanotechnology, optoelectronics, biotechnologies, advanced ceramics, metallurgy and chemistry (RM, 2011: 16-17). The 26-pages long document cannot be regarded as operational guidance for researchers or technology companies, and does not really offer clear priorities for R&D funding, instead listing multiple research fields, important for the international science and technology community.

The Council of NCBiR was supposed to implement the R&D priorities by means of strategic R&D programs. Interestingly, only several funding programs of NCBiR are defined as strategic (i.e. formalized in compliance with the legal requirement), while most of the R&D support instruments of NCBiR do not have this characteristic and are flexibly implemented by the Centre, but still remain consistent with the priorities set by KPB. In consequence, participants of the R&D&I system in Poland do not have clarity about the funding priorities in the coming years – KPB is very general, while NCBiR offers multiple more narrowly-defined programs. It should be remembered that the new responsibilities of NCBiR were assigned in 2010-2011, and the Centre is dynamically expanding its funding programs and scope of activities, negotiating additional funds for R&D from external stakeholders, and launching some programs on a pilot basis, in order to explore the possibilities within the national system of innovations.

In January 2013, the Ministry of Economy published a draft of the ***Enterprise Development Program*** **(PRP)** (MG, 2013). PRP is executive program for SIEG, and includes proposals for future policy measures, as well as structural and procedural changes within the public administration sector. The Ministry pointed to the excessive number of support measures for innovations, with overlaps creating confusion among potential applicants (MG, 2013: 7), and past preferences for supporting the absorption of new technologies, instead of funding the development of innovations (MG, 2013: 9-10). 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 (MG, 2013: 11, 17),
- centralising R&D support in central government agencies, and distributing funds for the absorption of innovations by regional institutions (MG, 2013: 23),
- preference for funding R&D projects related to technologies, which had been identified as key technologies in the *Technological Foresight of Industry – Insight 2030* (comp. sub-chapter 2.6) (MG, 2013: 43),
- preference for financing initiatives of consortia not individual organisations (MG, 2013: 44), thus stimulating the bottom-up development of business networks and partnerships between industry and academia,
- proposal to appoint PARP as the future co-ordinator and contact point for all public support measures for enterprises (MG, 2013: 16-17),

- 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 (MG, 2013: 12),
- attempts to introduce tax benefits for R&D performers (MG, 2013: 44-47),
- limiting support for the creation of new business clusters, focusing instead of stimulating their development with proportional involvement of private capital (MG, 2013: 72),
- strengthening linkages between science and industry, including support for internships of scientists in business enterprises and secondments of company employees in scientific institutions (MG, 2013: 75),
- creation of dedicated support measures related to ICT and environmental technologies, including promotion of open source software and active participation in the *EU Environmental Technology Verification* (*ETV*) programme (MG, 2013: 84).

The draft of PRP was sent for intergovernmental and public consultations, and the comments received are likely to influence its future contents, especially as they concerned the feasibility of some of the proposed support measures. Alongside with the PRP draft, the Ministry published also its formal evaluation by the World Bank, which critically evaluated some aspects of PRP, e.g. by arguing against the proposed appointments of specific organisations to co-ordinate the future R&D funding programs (Kapil et al., 2012: 47-48), or by suggesting that within the Polish fiscal system, the introduction of new tax incentives might increase the probability of tax inspections and be regarded as burdensome by enterprises, thus limiting the impact of the stimulus (Kapil et al., 2012: 60). PRP updates will also have to be synchronised with the on-going preparation of the Operational Program Smart Development (POIR), co-ordinated by the Ministry of Regional Development and involving an extensive dialogue with stakeholders.

The Minister of Science and Higher Education defines priorities related to large research infrastructure investments in the ***Polish Roadmap for Research Infrastructures*** **(PMDIB)** (MNiSW, 2011a). PMDIB includes 33 investment projects, selected in a nation-wide competition from 2009 and related to unique research infrastructure, key for specific R&D projects, and ICT infrastructure supporting the research efforts. The Roadmap helps consolidate the scientific potential in specific fields of research and rationalises the management of infrastructure, as it encourages the formation of research consortia to avoid the duplication of investments and stimulates the joint use of the funded infrastructure by multiple research teams. The inclusion in PMDIB does not guarantee the funding for a specific infrastructure investment, but is a pre-condition for an investment project to be considered for financing from the EU Structural Funds and strengthens the project's chances of being funded from the state budget. In January 2013, the Minister initiated a process of updating the Roadmap by issuing a new call for submissions from research institutions.

The preceding passages outline the ambiguous status of R&I priorities in Poland – the existence of policy documents, and at the same time, the lack of detailed priorities for R&D performers. The development of SIEG was preceded by an analysis of strengths and weaknesses, and inspired by multiple foresight projects. Nevertheless, it seems not to address some of the desired issues, important for the national system of innovations in Poland.

4.2 Evolution and analysis of the policy mixes

Table 3 presents a synthetic overview of instruments, introduced by the Polish government in the recent years. The structural reforms of science and higher education from 2010-2011 yielded substantial improvements in the structure of the policy mix. The portfolio of instruments is very comprehensive, but several intervention areas seem not to have been adequately addressed: R&D project loans (as the instruments available focus on subsidies instead), R&D friendly procurement, reform of IPR regulations, loan and equity guarantees for R&D investments (with limited availability of instruments, supported by the EU Structural Funds), R&D tax measures (as only tax incentives for technology implementation – not development – are prevalent), R&D-specific employment policies and subsidies for hiring R&D personnel.

Table 4. Overview of policy mixes, implemented in Poland, 2010-2012.

Type of instruments	Used?	Description
R&D policies		
Discretionary institutional funding for R&D projects	+	Institutional funding from the science budget, linked to performance (scientific outputs, successful commercialization of research results)
Competitive R&D project grants	+	Grants for basic research (NCN) and applied research (NCBiR), and additional funding from the EU Structural Funds (POIG)
Competitive R&D project loans	-/+	Limited availability – 'Technological Credit' (BGK) and loans for SMEs within the KSU system (not focused on R&D), while most R&D funding offered as subsidies
Support for R&D infrastructures	+	Intensified efforts by MNiSW to establish world-class research infrastructure through PMDIB
Selective support for centres of excellence	+	Newly introduced competition for KNOWs – leading scientific centres of excellence; R&D infrastructure investments through PMDIB help identify the most promising investment targets
Structural reform of PROs and PHEIs	+	Comprehensive reform of science and higher education system, including performance-based measures and induced competition for funding
R&D friendly procurement	-	Lack of relevant policies in the area is criticized by PROs and PHEIs, and public institutional customers have no incentives to purchase R&D-intensive solutions; no dedicated pre-commercial procurement regulations
Selective R&D support schemes for high tech and medium tech sectors	+	New support instruments by NCBiR and PARP, targeting specific industries and emerging technologies
RDI policies		

Type of instruments	Used?	Description
Collaborative R&D programmes	+	Many project grants require the formation of research consortia (NCBiR)
Technology platforms	+	Support for creation of technology platforms
Cluster policies and regional growth pole policies	+	Dedicated funding for technology clusters (PARP and regional instruments)
Support for science parks and other co-location schemes	+	Dedicated funding for science parks (PARP) and new foreign investments (PAIZ)
Support for other university-industry linkage mechanisms	+	Grant schemes requiring formalized co-operation (NCBiR), incentives for technology transfer from PHEIs and PROs (including additional funding and better institutional evaluation)
Support schemes for spin-offs	+	Operations of business incubators, funding from the EU Structural Funds, new instruments from NCBiR
Reform of IPR regulations	-	MG was supposed to improve the regulations and work on the establishment of a dedicated IPR court, but no activities could be observed
Finance policies		
Risk capital for R&D	+	Risk capital available from public institutions (KFK) and private sources (VC, business angels; access to NewConnect stock exchange market for innovative SMEs; new instrument combining public and private VC to be introduced in 2013 (NCBiR); political declarations but unclear plans to establish a state-owned holding company Polskie Innowacje S.A. (MNiSW); launch of sovereign investment fund Polskie Inwestycje Rozwojowe S.A. (PIR)
Loan and equity guarantees for R&D investments	-/+	Multiple instruments including technological credit (BGK) as well as loans and guarantees, funded from POIG and offered within the KSU system; the availability of these instruments is however not satisfactory and will be further restricted with the depletion of the EU Structural Funds at the end of the programming period; the instruments are also available to traditional companies, without preferences for innovative ventures
Tax measures supporting technology diffusion and innovation	+	Tax exemptions for implementation of innovative technologies
R&D tax measures	-/+	Limited benefits, available only to enterprises holding the legally-defined status of 'R&D centre';

Type of instruments	Used?	Description
		discussions about possible future fiscal incentives seem unrealistic due to the need to further reduce the public debt
R&D-specific Human Capital policies		
Efforts to make S&T more attractive to students	+	Awareness campaigns, funding for ordered study specialities and scholarship schemes (MNiSW)
Entrepreneurship training schemes	+	Wide availability (PARP, KSU, MNiSW and other institutions)
Support for lifelong learning	+	Wide-ranging support for postgraduate studies and training courses from the EU Structural Funds
Support for S&T post grads and post docs	+	Competitive research grants and scholarships (MNiSW, NCN, NCBiR)
R&D-specific employment policies	-	Lack of dedicated policies
Subsidies for hiring R&D personnel	-/+	Limited number and scope of instruments, supporting the employment of scientists by industry, financed from the EU Structural Funds
R&D mobility schemes	+	Support for mobility by provision of information, job offers, exchange programs for students and researchers, including international mobility (MNiSW)

Source: own, using the taxonomy based on: Guy et al. (2009: 13-14).

Strengths of the current policy mix include modern and performance-based support system for science and higher education institutions, including PROs and PHEIs. The system resulted from the recent institutional reform and requires several years to become fully functional, but already in 2012 R&D funds were distributed mainly based on competitive criteria, and public R&D performers were encouraged to closely co-operate with business enterprises.

More limited was the support for industrial companies, engaging in RDI activities. They could benefit from R&D project grants, but not from dedicated loans or loan guarantees, procurement regulations, tax incentives, or subsidies for hiring R&D personnel. The part of the policy mix, related to innovative enterprises, lacks systemic oversight or strategic approach. There are also problems with effective enforcement of IPRs, and public institutions did not live up to their earlier promises to establish a specialist IPR court. It is possible that these problems will be addressed and rectified by the Enterprise Development Programme, which is supposed to be prepared by the Ministry of Economy (Republic of Poland, 2011: 32).

4.3 Assessment of the policy mix

The policy mix in Poland seems to adequately address the needs for transformation of the PROs and PHEIs, but falls short of the necessary support for innovative business enterprises. Table 4 lists five previously identified structural challenges in the Polish RDI system, with policy measures adopted in order to address each of these challenges.

Table 5. Policy measures addressing structural challenges in Poland.

Challenges	Policy measures/actions addressing the challenge [2]	Assessment in terms of appropriateness, efficiency and effectiveness
(1) Low levels of business investment in R&D and in-house technological innovation	• New project grant schemes by NCBiR, increasing the share of private investments • (Uncertain) plans to increase the use of R&D loans instead of subsidies • (Uncertain) plans to offer tax incentives to R&D performers	Limited scope and effectiveness of the existing instruments with vague political declarations about the future plans for new instruments, which might not be implemented due to state budget cuts. Recent funding programs by NCBiR induced substantial new investments in R&D by business enterprises: €88.1m in 2011 and €306.3m in 2012 (MNiSW, 2013: 5). Enterprise Development Programme (PRP) not adopted yet, and the draft does no address the challenges in a systemic manner. Due to the situation of the state budget, new tax incentives seem unlikely.
(2) Limited synergies between the science and industry, restricting the innovative potential of the economy	• Co-operative research grants from NCBiR and public support for joint participation in FP7 • Evaluation of PROs and PHEIs depends among others on documented technology transfers to industry and co-operative projects • New institutional solutions, supporting the establishment of special purpose companies by PHEIs and scientific and industrial centres by PROs	Challenge addressed in the recent science and higher education reform, but results are yet to be seen. Business enterprises have limited confidence in local scientists, and without appropriate awareness campaigns, the synergies might be difficult to achieve.
(3) A need to concentrate financial	• KPB perceived as list of R&D priorities by the government • Strategic research programs by	Lack of genuine prioritization, with KPB being only a general list encompassing many broad research fields, and NCBiR

[2] Changes in the legislation and other initiatives not necessarily related to funding are also included.

Challenges	Policy measures/actions addressing the challenge [2]	Assessment in terms of appropriateness, efficiency and effectiveness
resources on key strategic areas and RDI priorities	NCBiR Council	launching consecutive research funding programs without a coherent, strategic plan, indicating priorities for applied research, while NCN distributed project funds for fundamental research through a bottom-up approach.
(4) Increasing internationalization and attractiveness of RDI system	• Multiple support instruments, stimulating international co-operation in scientific research (MNiSW) • Institutional reform of science and higher education facilitated the employment of foreigners without Polish academic degrees and titles • PAIZ attracting foreign investors, in particular to Special Economic Zones, which offer tax benefits related to new investments and labour costs for newly hired employees • 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. FDIs focus on production and service facilities, with only a small number of investors interested in R&D.
(5) Inducing knowledge spill-overs from foreign direct investments	• -	Many foreign investors are not adequately embedded within the national system of innovations, and policies designed to attract FDIs focus on the creation of new jobs; lack of relevant instruments such as requirements for local content or local partnerships.

Source: own.

The overview presented in Table 4 reveals that specific structural challenges have not been comprehensively covered by the wide range of existing policy instruments.

Successful coping with the structural challenge (1) depends on the implementation of announced instruments, including tax exemptions and loans used to phase out R&D subsidies. The implementation of R&D-related tax incentives seems unlikely in the coming years due to the plans for further budget cuts, intended to reduce the public debt, and relying among others on the gradual elimination of existing tax exemptions. Ministry of Economy was supposed to

prepare a major policy document, Enterprise Development Programme, outlining the proposed, strategic approach to the sector, but these plans did not materialize.

Limited synergies between science and industry (challenge 2) call for a significant change in perceptions and attitudes among participants of the national system of innovations. Even though the recent institutional reform of science and higher education introduced measures, encouraging scientists to initiate co-operation with business enterprises, many companies do not appreciate the potential benefits, or are cautious when dealing with PROs and PHEIs in light of earlier, disappointing experiences (comp. Bąk, Kulawczuk, 2009).

Challenge (3) is related to the imperfect prioritization in RDI policies, and was described in detail in sub-chapter 4.1. Policy documents, outlining priorities for R&D activities, are too general and do not offer sufficient guidance to organizations carrying out research and commercializing its results.

Internationalization and attractiveness of RDI system (4) remain important themes for public interventions, but Poland is not attractive for experienced foreign researchers, doctoral students and postdocs. In spite of recent legal changes, local regulations or traditions still prevent foreigners from pursuing careers in Poland. Besides, income levels in R&D sector are significantly lower than in many other EU countries, so the internationalization and mobility of the Polish RDI system mean rather emigration of the best Polish specialists than attracting foreigners.

Particularly problematic is challenge (5), related to spill-overs from FDIs – no dedicated measures can be identified, and the Polish government seems to focus on attracting investors mainly in order to increase the employment, without specific focus on R&D-driven investments. Accordingly, foreign investors tend to be attracted by the low income levels, locating in Poland manufacturing and service operations. PAIZ tries to attract more knowledge-based projects, including R&D centres, but there are no dedicated policy measures, which could facilitate these efforts and offer additional incentives to foreign companies.

5 NATIONAL POLICY AND THE EUROPEAN PERSPECTIVE

Polish government aims at aligning national policies with the key priorities of ERA (European Research Area), and the relevant developments are described below.

ERA priority 1: More effective national research systems

The recent science and higher education reform increased the importance of competitive funding for R&D. According to the 2012 science budget, 63.79% of the budget were distributed through competitions, and the institutional funding (32.84%) was allocated based on the results of scientific evaluation (comp. sub-chapter 2.2). Funds for basic research (13.48% of the science budget in 2012) are distributed by means of open, nation-wide competitions, managed by NCN, based on the bottom-up approach: applicants are free to define their preferred research topics without a need to address any pre-selected research themes, but should select one of 25 review panels, representing scientific disciplines. NCN has dedicated programs for young scientists, and accepts also applications from researchers not currently employed by scientific institutions or working for the industry. Applied research funding was distributed by NCBiR (39.18% of the science budget in 2012) by means of multiple programs with broad thematic focus, linked to the National Research Program (KPB) (comp. sub-chapter 4.1), as well as competitions in which applicants can independently select their research areas. NCBiR supports both academia and industry, and some programs require the formation of consortia between business and scientific institutions, or involvement of specialist companies tasked with commercialization of the research results. Program LIDER supports young researchers, offering them up to E478k for projects, intended to generate innovative technological solutions and establish new research teams. MNiSW issues open calls for proposals for other funding streams – investments in research infrastructure through the Polish Roadmap for Research Infrastructures (PMDIB) (comp. sub-chapter 4.1), funds for science promotion and international research co-operation. Institutional funding is also distributed based on competitive criteria, linked to the results of institutional evaluation, conducted by a dedicated committee KEJN, using transparent criteria, including bibliometric indicators (comp. sub-chapter 2.3).

Calls for proposals organised by NCBiR and NCN require applicants to submit research proposals in English and Polish (with the exception of selected basic research disciplines, including humanities). All applications are reviewed using standard peer-review principles, and discrepancies between individual reviews of the same application are additionally investigated. In many competitions, the applications are reviewed by foreign scientists, but the practice is restricted to the most significant calls for proposal due to the scale of operations. In 2011, MNiSW, NCN and NCBiR reviewed altogether 18,406 project proposals, and in 2012 – 16,102 proposals (MNiSW, 2013: 31). In particular, International reviewers are involved in the selection of R&D projects for the most experienced researchers, large research infrastructure investments and selection of the leading academic institutions (KNOWs, comp. sub-chapter 2.3). NCBiR co-operates also with international VC funds in one of its funding programs, ensuring that the

selected projects are not only scientifically sound but also have commercialisation potential in global markets.

it is worth noting, that the transformation of the R&D funding system in the recent years yielded impressive results, promoting the openness and transparency, encouraging international competitiveness of research, and increasing the number of researchers benefiting from public funding.

ERA priority 2: Optimal transnational co-operation and competition

The transformation in the Polish science sector involved increased international exposure, with project applications prepared partly in English, possibility of involving foreign reviewers, use of bibliometric indicators related to international co-operation and additional funding facilitating the involvement of Polish researchers in transnational research consortia. Policy documents value the importance of international competition in research areas, and many funding programs by NCBiR intend to increase the competitiveness of carefully selected, world class research initiatives. Regardless of the efforts, the involvement of Polish researchers in international initiatives is still limited when compared with their counterparts from Western European countries, especially when measured by FP7 participation, counts of joint scientific publications with foreign partners or joint transnational patents (comp. sub-chapter 1.4). The science budget includes dedicated funding streams for transnational R&D projects, but they are mostly intended to subsidize the participation of Polish research teams.

The National Research Program (KPB) (comp. sub-chapter 4.1) covers topics, congruent with most of the grand challenges, covered by the ERA priority 2, but they are mostly being addressed by national research projects. There are e.g. earmarked funds for research related to lifestyle diseases, low-carbon and environmental technologies and ICT. The R&D priorities were defined thanks to foresight programs (comp. sub-chapter 2.6) and the practice of mid-term and ex post evaluations became very common in the recent years (comp. sub-chapter 2.7). The Polish Roadmap for Research Infrastructures (PMDIB) (comp. sub-chapter 4.1) guides the efforts to develop the national and regional RI in line with the ESFRI (European Strategic Forum on Research Infrastructures) framework.

ERA priority 3: An open labour market for researchers

The legislation changes, accompanying the science and higher education reform, made it easier for Polish and foreign researchers to study and work in Poland.

Openness on the local level means introduction of publicly announced competitions for any new position at PROs and PHEIs, with MNiSW aggregating all job offers on its website. Academic careers are determined by the recently introduced legislations, with clear and transparent conditions for promotions and required timespans for progressing between specific career stages. Some funding programs additionally promote the mobility of researchers by encouraging to conduct R&D projects in organisations different than the home institution. The international mobility of Polish researchers is also close to the EU average (EC DGRI, 2011: 276).

Poland maintains multiple EURAXESS service centres and a website (www.euraxess.pl), offering support for incoming foreign researchers. The website lists job vacancies, as well as information about available research grants and fellowships. Apart from Marie Curie grants, programs available to foreigners are limited and focused on researchers from Central and Eastern Europe, Caucasus and Central Asia. Professor positions in Poland are now available to persons without Polish post-doctoral degrees (*habilitation*, "*dr hab.*" degree), providing that they can demonstrate substantial experiences in managing team research projects. Studies can be conducted in foreign languages and research theses can be prepared and defended in English. Unfortunately, research careers in Poland do not seem attractive when compared with opportunities abroad. Salaries of researchers in PROs and PHEIs are regulated by the government, stipulating maximum remuneration, which remains relatively low. In addition, R&D funding agencies NCN and NCBiR introduced recommendations for maximum remuneration levels in the funded projects, and the levels might discourage the participation of foreign specialists.

ERA priority 4: Gender equality and gender mainstreaming in research

Polish research system is inclusive from the perspective of gender (comp. data presented in sub-chapter 1.3), and the equal treatment of both genders is culturally rooted in the old, socialist tradition of equal access to jobs. There are no publicly known targets, related to gender parity and required representation of women in scientific committees, but the share of women in R&D sector (40%) is significantly higher than the EU-27 average (32%) (EC DGRI 2012: 230), and there are more women than men students and higher education graduates. Nevertheless, women account for a minority in business enterprises R&D positions, as well as S&E students and researchers. MNiSW organizes annual competitions for female S&E students, in co-operation with one of female magazines, and sets examples of successful female researchers in various promotional materials.

ERA priority 5: Optimal circulation and transfer of scientific knowledge

MNiSW offers extensive support for the circulation of knowledge linked to the mobility of researchers, and multiple policy instruments stimulate the involvement of Polish researchers in projects led by foreign institutions. With regard to codified knowledge, the government has been focusing on the assignment of IPRs to the R&D performers, facilitating transfers and commercialization, but also making the knowledge and innovations proprietary. MNiSW and other government institutions funded small-scale projects, testing the possibilities of granting open access to specific publications. Another step towards the openness is the legal requirement to publish online contents of PhD theses. The issue of unrestricted access to knowledge and content gained particular prominence due to the very visible protests against the ACTA agreement in early 2012 (comp. sub-chapter 2.1). Access to public information is facilitated through formal legal procedures, which oblige public administration (including PHEIs and PROs) to share the information and data in response to individual requests. In order to facilitate the procedures and aggregate all relevant data on a widely available Internet platform, the

Ministry of Administration and Digitisation is working on a bill, granting open access to publicly-funded research findings and plans to adopt it in 2013.

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LIST OF ABBREVIATIONS

ACTA	Anti-Counterfeiting Trade Agreement
ARP	Industrial Development Agency (Agencja Rozwoju Przemysłu)
BERD	Business Expenditures for Research and Development
BGK	Bank Gospodarstwa Krajowego
BPO	Business Process Outsourcing
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
ETV	European Union's Environmental Technology Verification
EU	European Union
EU-27	European Union including 27 Member States
FDI	Foreign Direct Investment
FNP	Foundation for Polish Science (Fundacja 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 Institutions
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)
KNOW	National Scientific Leading Centre (Krajowy Naukowy Ośrodek Wiodący)
KPB	National Research Programme (Krajowy Program Badań)

KPK	National Contact Point for Research Programmes of the European Union (Krajowy Punkt Kontaktowy Programów Badawczych UE)
KPN	Committee for Science Policy (Komitet Polityki Naukowej)
KRASP	Conference of Rectors of Academic Schools in Poland (Konferencja Rektorów Akademickich Szkół Polskich)
KSU	National Service System for Small and Medium-Sized Enterprises (Krajowy System Usług)
MF	Ministry of Finance (Ministerstwo Finansów)
MG	Ministry of Economy (Ministerstwo Gospodarki)
MNiSW	Ministry of Science and Higher Education (Ministerstwo Nauki i Szkolnictwa Wyższego)
MRR	Ministry of Regional Development (Ministerstwo Rozwoju Regionalnego)
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)
PKA	Polish Accreditation Committee (Polska Komisja Akredytacyjna)
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 Development (Program Operacyjny Inteligentny Rozwój)
PRO	Public Research Organization
PRP	Enterprise Development Program (Program Rozwoju Przedsiębiorstw)
PSL	Polish People's Party (Polskie Stronnictwo Ludowe)
R&D	Research and development
RGIB	Main Council of the Research Institutes (Rada Główna Instytutów Badawczych)

RGNiSW	Main Council of Science and Higher Education (Rada Główna Nauki i Szkolnictwa Wyższego)
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)
S&E	Science and engineering
S&T	Science and technology
SF	Structural Funds
SIEG	Strategy for the Innovation and Effectiveness of the Economy (Strategia Innowacyjności i Efektywności Gospodarki)
SME	Small and Medium-sized Enterprise
SSE	Special Economic Zone
VC	Venture Capital

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Abstract
This analytical country report is one of a series of annual ERAWATCH reports produced for EU Member States and Countries Associated to the Seventh Framework Programme for Research of the European Union (FP7). The main objective of the ERAWATCH Annual Country Reports is to characterise and assess the performance of national research systems and related policies in a structured manner that is comparable across countries.
The Country Report 2012 builds on and updates the 2011 edition. The report identifies the structural challenges of the national research and innovation system and assesses the match between the national priorities and the structural challenges, highlighting the latest developments, their dynamics and impact in the overall national context. They further analyse and assess the ability of the policy mix in place to consistently and efficiently tackle these challenges. These reports were originally produced in December 2012, focusing on policy developments over the previous twelve months.
The reports were produced by independent experts under direct contract with IPTS. The analytical framework and the structure of the reports have been developed by the Institute for Prospective Technological Studies of the Joint Research Centre (JRC-IPTS) and Directorate General for Research and Innovation with contributions from external experts.

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As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new standards, methods and tools, and sharing and transferring its know-how to the Member States and international community.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.

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