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Specific Support to Bulgaria

The research evaluation and performance-based funding system in Bulgaria

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The research evaluation and performance-based funding system in Bulgaria

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EUROPEAN COMMISSION

Specific Support to Bulgaria

The research evaluation and performance-based funding system in Bulgaria

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2018 Directorate-General for Research and Innovation EN

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List of Abbreviations

Abbreviation	Full name
AA	Agricultural Academy
BAS	Bulgarian Academy of Sciences
BG	Bulgaria
BGN	Bulgarian Lev (currency)
CNEAI	National Commission for the Evaluation of Research Activity
EC	European Commission
EIS	European Innovation Scoreboard
ERIH	European Reference Index for the Humanities
ESIF	European Structural and Investment Funds
EU	European Union
EUA	European University Association
FDI	Foreign Direct Investment
FP	Framework Programme
FTE	Full-time equivalent
GBAORD	Government budget appropriations or outlays for research and development
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GS	Google Scholar
GUF	General University Funds
HE	Higher education
HEI	Higher education institute
IP	Intellectual Property
IPR	Intellectual Property Rights
JIF	Journal Impact Factor
JRC	Joint Research Centre
MAF	Ministry of Agriculture and Food
ME	Ministry of Economy
MES	Ministry of Education and Science
NSI	National Statistical Institute
OECD	Organisation for Economic Co-operation and Development
OP	Operational Programmes

Abbreviation	Full name
PA	Performance Agreements
PBRF	Performance-Based Research Funding
PRFS	Performance-based Research Funding Systems
R&I	Research and innovation
RIS	Research Information System
RTO	Research and Technology Organisations
SSH	Social sciences and humanities
TNO	Organisation for Applied Scientific Research (NL)
VTT	Technical Research Centre (FI)

The PSF Specific Support panel

Luc Soete, Chair, is board member of the UNU-MERIT and until September 2016 was Rector Magnificus at Maastricht University. Before that he was Director of the United Nations University research and training institute: UNU-MERIT located in Maastricht, the Netherlands and Professor of International Economic Relations and Director-Dean of the Maastricht Graduate School of Governance (MGSoG) at Maastricht University. He is a member of the Advisory Council for Science and Technology Policy (AWT) and the Royal Dutch Academy of Science (KNAW). He was also the Chair of the H2020 PSF Peer Review of Bulgaria in 2016.

Bea Mahieu, Rapporteur, is senior consultant at the Technopolis Group and has close to 20 years of experience in delivering advice to research and innovation policymakers. Her key expertise is in the analysis, evaluation and impact assessment of research and innovation governance systems, policies and programmes, at both the European and national level. Her recent work includes a study for the European Parliament STOA office analysing the use of science metrics and research information and performance management systems in the European Union Member States and a study for the Ministry of Education in the Czech Republic resulting in the actual design of a new national R&D evaluation and institutional funding system in the country. She was a member of the Technopolis team conducting a study in support of the review of the Research Excellence Framework in the UK, commissioned by the Department of Business, Energy and Industrial Strategy (BEIS).

Terttu Luukkonen, Expert, was Chief Advisor and, before that, Head of Unit at the Research Institute of the Finnish Economy (until end of November, 2015). She has previously held positions with the Technical Research Centre of Finland (Chief Research Scientist, Director of VTT Group for Technology Studies, 1995-2001) and the Academy of Finland (1974-1995). Her expertise covers a wide range of issues in research and innovation policy in Europe. She has evaluated and researched activities related to public programmes promoting university-industry relations, knowledge transfer, research collaboration, measurement of research excellence and the dynamics of science. Her long-time field of expertise is related to evaluation, both methods, techniques, use made of, and impacts of evaluations of public support for RTD activities.

Erik Arnold, Expert, is co-founder and Chairman of the Technopolis Group, Adjunct Professor in Research Policy at the Royal Institute of Technology, Stockholm, and a Visiting Academic at the University of Manchester. He is a Trustee of the Fraunhofer-ISI institute and a member of the editorial board of the journal *Research Evaluation*. He has worked in research and innovation policy and evaluation since 1980, covering a wide range of disciplines handling research and innovation policy. His work spans over 30 countries as well as the European Commission and a range of international organisations including the OECD, World Bank, Nordic Council of Ministers, ESF and COST.

The expert team was supported by Ruslan Zheckov who authored the background report for this study. The experts were also supported by the PSF Team comprising the PSF contractor (represented by Ruslan Zheckov, project manager at Technopolis Group) and the Commission services (DG Research and Innovation, Unit A4 – 'Analysis and monitoring of national research policies') with Diana Ivanova van Beers as the contact point, who coordinated the exercise and ensured liaison with the Bulgarian authorities.

The Bulgarian authorities made available data and background documentation useful for the panel's work and supported the visit to Bulgaria.

The Horizon 2020 Policy Support Facility

The Horizon 2020 Policy Support Facility (PSF) is an instrument aimed at supporting Member States and countries associated with Horizon 2020 in improving the design, implementation and evaluation of their national research and innovation (R&I) policies and systems. The PSF was set up by the European Commission, DG Research and Innovation (DG RTD), under Horizon 2020.

Specific support services provide tailored advice, expertise and good practice to help Member States and Associated Countries in the design or implementation of a specific reform or topic concerning R&I strategies, programmes or institutions. This is carried out by an international and independent expert panel which formulates concrete and operational recommendations for the national authorities on the reforms necessary to address the specific objectives.

KEY POLICY MESSAGES AND RECOMMENDATIONS

We identified the following key policy messages and recommendations that underpin the more detailed recommendations in this report:

1. **A structural reform of the Bulgarian research landscape is an absolute pre-condition for any Performance-based Research Funding System (PRFS) to be effective.**

- We recommend the Bulgarian authorities to address the fragmentation in the research system in a direct manner. This should entail a concentration of the higher education sector and, in order to reap the full benefit of the Academies' research capacity, a system-wide reform creating synergies in the system based upon the missions of the research organisations.
- We suggest a new research landscape ultimately comprising a maximum of some 10 to 12 research players, including 5 to 6 new 'research universities' and 5 to 6 new 'entrepreneurial universities'.
- The Bulgarian authorities are invited to substantially increase the public funding of research. Doubling it would be a reasonable target, in the context of the scale of the problem. The additional funding would be earmarked uniquely for the 10-12 new universities

2. **Refine the current PRFS design to ensure the introduction of a fair, transparent, simple and low-cost PRFS.**

- We recommend the Bulgarian authorities to strengthen their use of the PRFS as a *policy tool*. Incentives should be created to encourage behavioural changes related to the major structural failures in the research system (e.g. research-industry collaboration) for the PRFS to fulfil its function in supporting the recovery of the Bulgarian research system.
- We recommend taking a broader view on the concept of 'quality' in research and considering the relevance of research for industry and society as inherent to the concept of research 'quality', in the case of 'targeted' fundamental research, too.
- We recommend making the necessary adjustments to the evaluation methodology *before it is used to inform the distribution of institutional funding for research*. Significant improvements are needed especially in the approach to field-normalisation, the definition of indicators, and the definition and delimitation of data sources.
- The current use and design of the 'scientific impact' indicators should be drastically revised. It is our opinion that the use of the JIF-based indicators and the h-index indicator is ill-advised. We recommend that these indicators be withdrawn from the evaluation methodology.
- We recommend that the Bulgarian authorities take stock of the experiences abroad and make more use of external professional expertise. We especially recommend seeking the support of bibliometric experts for the construct of field-normalised or field-independent citation indicators.

- Before introducing a fully-fledged performance-based research funding system, we recommend that the Bulgarian authorities finalise and refine the definition of minimum threshold levels for the inclusion of research units in the PRFS.
- We also recommend refining the volume measure, based on an improved definition of the term 'researcher' and an agreement in the research community on how to count the 'full-time' dimension in the higher education institutes (HEI).
- We recommend developing a score system that ensures the indicators' equal influence on calculating the scores against the assessment criteria, as well as enhancing the strategic value of the evaluation outcomes and the transparency of the evaluation process.
- Policy decisions need to be taken related to the weights of the different assessment criteria in the funding formulae *after* a revision of the indicators and a refined grouping of the indicators around assessment criteria.
- In its decision-making on the share of the institutional funding informed by the PRFS, we recommend the Bulgarian authorities aim at maintaining a balance between competition among the research-performing actors, stability in research funding, and restructuring of the research system to ensure quality while keeping the research system up to date, functional and relevant.
- We recommend the assessment of individual researchers to be based on a qualitative judgement of their portfolio and research activities by means of peer review, involving (more than one) experts in the specific field. It should take a holistic view on the research activity and go beyond the production of scientific outputs or impacts. JIF indicators and the h-index should not be used.

3. **Design an integrated evaluation and research funding framework.**

- We advise the Bulgarian authorities to create an integrated evaluation system where the 'main' evaluation would be peer review-based. It would allow for the creation of complementarities between the metrics- and the peer review-based exercises, whereby the strengths of each of these evaluation models can be exploited, and their weaknesses avoided.
- We urge the Bulgarian authorities to move gradually towards full English reporting of research outputs. In our view, a scheme of systematic self-assessment should be introduced as a pilot exercise and the first step in the preparation for international external peer assessments.
- We recommend putting a special unit in charge of the evaluations, created for the purpose, which has the necessary capacity and resources and can make use of the country's best of expertise. It should be supported by external expertise in indicator development and analysis, especially in the field of bibliometrics.

SUMMARY

This H2020 Specific Support Action discusses options for introducing a performance-based research funding system (PRFS) in Bulgaria, its design and implementation, and possible models for a more systematic assessment and evaluation of public research institutions.

The action has been carried out at the request of the Bulgarian authorities by an expert group funded under the European Commission (DG RTD) Policy Support Facility. It is based on document analysis as well as interviews with key stakeholders, including a visit by the group to Bulgaria, during the course of 2017. It has subsequently been discussed with the Bulgarian authorities.

State research-performing organisations normally obtain two kinds of research funding: 'institutional' funding from government, and 'external' funding from other funders, such as research councils, innovation agencies, charities, foundations and business. Performance-based funding refers to the institutional funding component that is allocated according to past performance, as opposed to unconditional block funding or to core grants based on forward-looking performance contracts or agreements. PRFS is one of the central mechanisms through which many EU Member States have tried to increase the effectiveness and performance of their public-sector research systems in recent years.

A PRFS consists of two core components: it has an assessment process, which judges research outputs based on their scientific quality and increasingly other criteria, too; and a funding formula which allocates institutional funding for research among the universities based on the results of the assessment. The policy objectives of a PRFS drive how the assessment and funding system work. They define the focus of the evaluation, the choice of the indicators, the definition of the 'units of assessment', and the criteria for allocating the funding.

The performance-based research funding system is still under development in Bulgaria. So far, a national evaluation methodology has been defined and is being piloted for use in a PRFS. The elements of the funding component defined to date are the formulae for calculating the final assessment scores and the algorithm to define the ranking of the institutions according to five categories, which will ultimately define their shares of the funding. The proportion of institutional funding that is to be governed by the PRFS has yet to be defined.

The context

Bulgaria's research and innovation (R&I) system faces serious challenges that urgently require policy intervention. The system is weak, mainly because of the significant public underfunding of research, shortcomings in the tertiary education system and a decline in research capacity. These factors influence the quality and applicability of the research undertaken and national capacity to compete in science at the EU and global levels.

As noted in the 2015 PSF Peer Review, the Bulgarian R&I system is characterised by a high level of **institutional fragmentation**, especially in the HE sector, and there is an acute – and long-standing - problem related to national **funding for**

research. For many years, public funding for research in Bulgaria has represented no more than 0.25 % of GDP and was among the lowest in the EU-28[1].

Knowledge circulation between and among universities, research institutes and the business sector is a major challenge. The poor link between the research and teaching components of the 'knowledge triangle' in Bulgaria threatens both the quality of education and the expansion of national research capacity. Research-industry links are impeded by lack of a critical mass in research-performing industrial actors and the low technological absorptive capacity of the domestic private sector.

Finally, there is widespread lack of trust in the R&I system among policymakers and the public at large, who remain broadly unconvinced of the potential for research to contribute to sustainable socio-economic growth in Bulgaria. This lack of trust is reflected, amongst other things, in the particularly low level of researcher salaries and in the low – and declining - priority the government allocates to knowledge creation in general.

Conditions for an effective PRFS

The high level of fragmentation of research is one of the most fundamental failures in the Bulgarian R&I system, causing a dispersion of the already minimal national research funding, amongst other issues. The approach for addressing this structural failure suggested in the 2017 National Strategy consists in a policy of 'passive adoption', i.e. relying on changes in the funding system (the PRFS) and other **indirect** measures for a gradual change, rather than trying to actively restructure the system. In this context, the current thinking about introducing a PRFS seems to be based on the assumption that the fragmentation of the research system will be reduced by focusing funding on excellent research.

The gravity of the current challenges in the Bulgarian R&I system and the extent to which the fragmentation is embedded in the cultural and political environment, however, lead us to consider that such a 'passive' or 'indirect' restructuring of the Bulgarian research system is not a viable option. While a PRFS can make a *contribution* to system restructuring, it is unlikely that alone it could correct the various inefficiencies, overlaps and systemic failures in Bulgaria's research system quickly enough and profoundly enough to reverse the current path of decline in the system. Unless the PRFS is combined with a structural reform, it cannot be expected to help overcome research fragmentation.

In the view of this expert panel, for the successful introduction of a performance-based research funding scheme as proposed in the PSF Peer Review, the Bulgarian research system has first to be reformed in terms of reaping minimum-scale advantages. The realisation of the essential minimum-scale conditions for research, reaping synergies and scale advantages across both disciplines and institutions, is essential for the successful introduction of a more quality- and performance-based funding system. However, realising such conditions will only

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[1] In 2015, Bulgarian GDP was €45.3bn with total public funding for research (some €113.25m) distributed among nearly 150 research facilities, i.e. less than 750K per institute.

be feasible if the Bulgarian authorities are prepared to bring about a **major structural transformation and concentration of research activities**. We believe that such a structural transformation is a precondition for any PRFS exercise to be effective.

In the last decade, public authorities in several countries have promoted mergers and concentration processes – among or between HEIs and research institutes - as a tool to accomplish a system-level reform. A trend towards the creation of closer links between research institutes and universities is visible in most European countries and, since 2000, mergers or concentration processes have occurred or been discussed in a large majority of Europe's national research systems. International experience shows that government has an important but delicate role to play in these concentration processes. Policy support for the merger and concentration processes is of fundamental importance, including the availability of additional financial resources for the institutions involved to prepare and organise the process.

In Bulgaria, we see the need for a concentration of the HE sector, and, in order to reap the full benefit of the Academies' research capacity, a system-wide reform creating synergies in the system - based upon the missions of the research institutes and universities.

It is possible to imagine a Bulgarian HE landscape consisting of four 'research universities' competing at European and global level with the rest of the world - both in high quality, excellent research and postgraduate education - and four 'entrepreneurial universities' focusing more on the valorisation of research, the creation of new enterprises and university spin-offs, and, more broadly, teaching entrepreneurial skills across all disciplines. To exploit more fully the research excellence of the Bulgarian Academy of Sciences (BAS) and Agricultural Academy (AA) institutes, a two-fold structural transformation of the Bulgarian research institute sector can be envisaged. Most BAS and AA scientific institutes are fully integrated within the Bulgarian university framework, either on their own through the creation of two 'academic research universities' or within the newly structured Bulgarian university landscape by 'bolting' the more technologically oriented research and technology organisation-type institutes (RTOs) to the 'entrepreneurial universities'.

It is important to stress that in order to achieve maximum stakeholder support for the reforms proposed here, such a restructuring must be accompanied by a **significant increase in the public funding for research** in Bulgaria, as was also strongly argued for in the 2015 H2020 PSF Peer Review report. We suggest that the Bulgarian government commits itself **at short notice** to an increase in its annual public funding for research with some €100 million, effectively a doubling of public research funding. Such an increase in public funding should be conditional on implementing the structural reforms proposed here.

The design of the current PRFS

In a PRFS, the criteria and indicators used in the evaluation are selected to reflect the goals the policies aim to promote. The expectation is that rewarding specific behaviour patterns or outputs will change the behaviour of the individuals, groups, and institutions under evaluation. The assessment criteria and indicators should therefore reflect the PRFS policy purposes, which may change over time**.** In order to create their intended effects and to be accepted and endorsed by both policy-makers and research performers, PRFS should be first and foremost be **fair**, **transparent, simple,** and **low cost.**

In terms of the **purpose of the PRFS**, the Bulgarian PRFS has many commonalities with others in the international landscape, specifically in its focus on enhancing research quality and competitiveness, combined with strengthening accountability. However, it distinguishes itself by its explicit and close-to-exclusive focus on scientific research and the potential effects of the research activities in the scientific sphere.

This is expressed in the choice of indicators which appears to be based predominantly on priorities internal to the research system (quality/excellence of research) with little regard for the importance of knowledge exchange with actors external to the research community and for the relevance of research, be it for industry or society at large. This generates a very narrow conception of 'accountability', linked solely to the traditional, internally centred conception of a research institution and paying no attention to its interaction with the other parts of the knowledge triangle. This is unlikely to persuade either the taxpayer or the government that scientific research should be funded not only in its own right but also because it generates pay-offs for society.

In addition, the evaluation methodology does not appear to address the systemic effects, both positive and negative, that research funding linked to performance may have. Nor does it attempt to incentivise behavioural changes over and above better quality and international presence. Thus, crucial aspects of research system performance, such as the relevance of research to societal needs and its impact upon these needs, and collaboration in research, are not being addressed.

The strong focus on research excellence, understood mainly as international competitiveness, risks exacerbating rather than addressing important current failures in the system such as the brain drain, lack of research capacity and productivity and the lack of research-teaching and research-industry links. The strong focus on internationally relevant research outputs risks creating a 'horizontal fragmentation' in the national R&I system, i.e. a concentration of the funding on 'islands of excellence' in research that locally are not necessarily relevant.

The assessment methodology is in need of major improvements in the **choice and design of the indicators** used. The fairness of an evaluation mainly depends on the extent to which it takes account of the differences in disciplinary cultures, expressed in terms of output types, main publication patterns, channels and timelines, citation behaviour, language of publication, collaboration behaviours and needs, intensity of the use and need of (human and financial) resources and research infrastructure, etc. The current evaluation methodology in Bulgaria shows significant shortcomings from this perspective, including the lack of a weight system for bibliometric indicators and field-normalised indicators. In addition, the one-year referencing period used in the Bulgarian PRFS (for all indicators) is highly unusual and problematic, especially for the citation indicators. Data available on an annual basis cannot convey an appropriate comprehensive view on research performance or progress. In PRFS, the effects of fluctuations in the research funding and a gaming of the system must also to be taken into account. Internationally, the norm is that the assessment takes into consideration research activities over a longer period – typically three to four years prior to the evaluation. The current use and design of the 'scientific impact' indicators is highly problematic. There are various issues, ranging from the lack in field-normalisation and use of an appropriate citation window to the need for a definition of the indicators and a delimitation of the sources for the citation data. Most important, the bibliometrics research community has repeatedly published recommendations not to use journal impact factor (JIF) indicators and the h-index in the context of research evaluations, while these indicators constitute the core of the research output assessment in the Bulgarian PRFS.

A **precise definition and delimitation of quality sources** for data collection is critical in a PRFS, not only because it should guarantee the quality of the data provided, but also because it should avoid encouraging a proliferation of articles published in second-tier journals that aim merely to increase the number of articles published without ensuring scientific quality. In the Bulgarian PRFS, the definition of the sources for the bibliometric data is problematic especially for the productivity and citation data. Internationally, various solutions have been found to overcome the well-known limits of the commercial databases, based on a distinction between citation databases and article databases as sources for specific indicators. These include the creation of 'databases of approved sources' and the extended use of national 'current research information systems' (CRIS).

An element of the **PRFS funding component** requiring a policy decision *prior to the introduction of any PRFS* in order to reach a more concentrated allocation of the institutional funding and a more cost-efficient evaluation process, is the definition of minimum threshold levels that would entitle research units to participate in the PRFS. Such minimum-scale level requirements contribute directly to reducing the incentives to fragment research activities, make the lower-performing parts of the system more visible, allowing them to either improve or disappear, and provide an overall framework for addressing field-specific considerations. They can also form the basis for restructuring the Bulgarian research system. In our opinion, one component of the PRFS funding formula which needs urgent refining is the volume measure. These measures are components of the funding formulae by which the size of a unit of analysis is taken into account when calculating the funding. Due to the definition of the 'researcher' position, in Bulgaria, the current use of the 'number of researchers' as a volume measure is highly inaccurate. An improved definition would provide for a fairer distribution of the funding, based on the 'real' capacity for research within the institutions. It would also allow for a more accurate view of the country's research capacity. A key decision required in the design of a PRFS is the approach used for the score system, i.e. the calculation of the scores against indicators and assessment criteria. Set against the international practice, the current approach in the Bulgarian PRFS to define the scores against the indicators by taking only the volume values into account (e.g. the number of publications or number of patents) is highly unusual. This approach creates a 'random weighting' of the indicators when calculating the scores against the assessment criteria, determined by the typical size of their 'value' only (for example, typically, more publications are produced than patents, so in the Bulgarian approach, publications have a higher weight for the calculation of the 'research outputs' score than patents). It also implies that the performance of a unit of analysis against the different indicators cannot be compared, for example to establish strengths and weaknesses. It therefore inhibits the correct use of evaluation outcomes to take 'corrective' actions and improve the units' research strategies while considerably limiting the transparency of the evaluation process. Furthermore, it is the combination of assessment criteria and weights set on indicators and criteria that allows PRFS to provide an all-round assessment while nevertheless prioritising the most urgent failures in the system. We see the current lack in weights linked to the indicators and assessment criteria in the Bulgarian PRFS as further illustration of its limited use as a policy tool, in sharp contrast to the practice internationally. In a PRFS, policy goals should define not only the choice of the indicators but also the weights allocated to each of the assessment criteria, making explicit their relative importance. Current policy documents in Bulgaria do not indicate the intended share of the performance-based funding of research within the budget for the institutional funding of research and within the overall research funding budget. These are important lacunae affecting aspects of the PRFS design.

The 2017 National Strategy suggests also installing a two-component financial system for **individual researchers**. Like the research institutions, individual researchers would undergo a 'periodic attestation', the results of which would drive part of their salary. The impression is that this personal assessment will be based on the (biblio)metric indicators currently used in the PRFS. In the panel's view, this is not advisable. Evaluation of individual performance must take into account a holistic picture of each individual's activities and the resources s/he has at their disposal; it should also have a forward-looking component. The evaluation should be based on a qualitative judgement of their portfolio and research activities by means of peer review, involving (more than one) experts in the specific field. The criteria for the assessment should go beyond the production of scientific outputs (quantity and/or quality) and include involvement in knowledge-transfer activities - in the research community or in education, for the benefit of industry and/or society.

An integrated performance-based research funding system

The 2017 National Strategy envisages the conduct of two types of evaluation exercises in future: namely, a metrics-based 'periodic attestation' and a peer review-based 'independent international evaluation'. It is the panel's opinion that it would be beneficial to develop an **integrated evaluation system** whereby the two evaluation exercises would build upon and complement each other and would **both** be integral to the performance-based research funding system. Three scenarios can be envisaged for this integrated evaluation system, depending on: 1) which of the two evaluation exercises will function as the 'main' evaluation and govern the performance-based component of the institutional funding system; and 2) the function of the other evaluation exercise.

We propose an international panel evaluation, based upon informed peer review, to carry out the function of main evaluation exercise, governing the performance-based part of the institutional funding for a period of five years, with minor annual adjustments to reward progress, based on a metrics-based monitoring system. This approach would allow the quality of the institutional research environment to be included in the criteria driving the performance-based component of the institutional funding. It would also enable a sharper focus of the metrics-based periodic assessment on the system's most urgent failures which need to be addressed.

Self-assessment will be an important component of the international panel evaluation. It should involve transparent questions which have been clearly explained by the PRFS managers. There will probably be significant differences in 'evaluation culture' among the research institutions in the Bulgarian system as well as in the adequate knowledge of English. Thus, groups with little evaluation experience and/or knowledge of English risk being at a disadvantage.

An important condition for the use of the peer review-based model as the main evaluation is the capacity and expertise of the entity responsible for implementing the evaluation exercise. A national peer-review exercise is complex and labour-intensive. This entity should also be in charge of designing and updating the evaluation methodology, including the metrics-based assessments.

1 INTRODUCTION: OBJECTIVES, METHOD AND SCOPE

This H2020 Specific Support Action discusses options for introducing a performance-based research funding system (PRFS) in Bulgaria, its design and implementation, and possible models for a more systematic assessment and evaluation of public research institutions.

1.1 Objectives and method of this study

This H2020 Specific Support study follows up on a Peer Review of the Bulgarian Research and Innovation (R&I) system conducted in 2015 (EC, 2015). The independent expert panel responsible for that peer review addressed the need for structural reform in the Bulgarian R&I system to boost the efficiency and quality of Bulgarian research and included recommendations for better research assessment and necessary reforms in the research funding system.

Recommendation 2.5 of the 2015 Peer Review addressed the need for performance-based funding for public research organisations (PROs).

> *"The present model for funding Bulgarian higher education and research organisations is clearly inadequate when it comes to supporting research and encouraging building up high-level research environments. The Policy Support Facility (PSF) panel recommends moving to a progressively higher concentration of resources based on performance-based funding, to facilitate transparent, fair and efficient allocation of resources and enhancing incentives for high research performance. In order to develop such a model, the panel therefore recommends that Bulgaria considers specific support under the PSF to provide concrete recommendations as to how to address this issue." (p.41)*

Following the final delivery of the Peer Review in autumn 2015, the Bulgarian Ministry of Education and Science (MES) expressed its interest in following up this recommendation. It asked DG RTD for a "specific support" study under the H2020 PSF to assist it in the reform of the Bulgarian R&I system, focusing in particular on the system for allocating institutional funding.

Thus, the terms of reference of the present H2020 Specific Support study define its aim as to "provide support to the Bulgarian authorities in the development of, 1) a research performance-based funding system, inspired by Member States' best practices, 2) a model for the evaluation and assessment of the public research organisations' performances". The present report discusses the various options for introducing a PRFS in Bulgaria, its design and implementation, and possible models for a more systematic assessment and evaluation of PROs.

This report is based on a background report, summarising and synthesising available policy documents and studies, and interviews with relevant policymakers and stakeholders, including a three-day visit to Bulgaria. The PSF expert panel worked from February 2017 to January 2018.

1.2 The focus of the study: PRFS

Performance-based funding refers to the component in the organisational level funding system allocated on a *competitive basis*, as opposed to block funding and/or to core grants based on performance contracts/agreements. The introduction of a PRFS is one of the central mechanisms through which many EU Member States have tried to increase the effectiveness and performance of their public-sector research systems in recent years. The efficiency of funding in terms of the capability to meet certain policy goals in a cost-effective way has become increasingly important.

PRFS are implemented in many different ways and can be complex. However, they share an underlying structure. A PRFS consists of two core components. First, it has an assessment process which judges research outputs based on their scientific quality and increasingly other criteria, too. The results of the assessment feed into the second component, a funding formula. Common to these formulae is that they move money away from those research institutions achieving low assessment ratings towards those rated more highly.

PRFS are important **policy tools** for research governance as they provide policy-makers with the opportunity to address failures in the national system while recognising the autonomy of the research-performing and/or HEIs in deciding on their institutional strategies, management practices and internal resource allocation. They aim to incentivise those governance/decision/behavioural processes within the research organisations which are able to stimulate and achieve high(er) performance in relation to selected criteria (for instance, by increasing the volume or quality of research output, prioritising certain fields of research, developing greater interaction with industry, fostering internationalisation or improving gender balance). PRFS may also be a way of concentrating resources in the best-performing organisations.

The **policy objectives** of a PRFS are therefore at the core of the system. They drive how both the evaluation and the funding system work. They define the focus of the evaluation, the choice of indicators, the definition of the 'units of assessment', and the criteria for allocating the funding. The **policy context** of a PRFS is a critical factor that drives performance-based research funding systems - and explains differences among the systems in international practice.

1.3 The structure of this report

A study aimed at assessing the design and implementation of a PRFS to identify areas for improvement must first set the PRFS within its broader **context and background.** In Chapter 2, we investigate the main challenges in the R&I system that the PRFS aims – or should aim – to address, and describe Bulgaria's current research evaluation and funding system.

We argue that urgent measures are needed in the Bulgarian research system to set out the **conditions** for the implementation of an effective, quality PRFS. We describe these measures in Chapter 3.

In Chapter 4 we set out our view on how the **design of the current PRFS** can or should be refined.

Chapter 5 concludes the report with an overview of the key principles for a quality PRFS and sets out the options for the design of an **integrated PRFS**.

2 THE CONTEXT

This chapter sets out the background to the study. We briefly summarise the main characteristics of the socio-economic environment around the Bulgarian research system and describe the main challenges and failures in the Bulgarian research system. The specific focus is on those challenges upon which PRFS in the international landscape typically try to intervene. In the last section we give an overview of the policy context, specifically related to the evaluation and funding of research.

2.1 The socio-economic context

As with other countries in Central and Eastern Europe (C&EE), Bulgaria was hit particularly hard by the financial crisis of 2008, leading to a contraction of GDP by 4.5%. The economy started to grow again after the crisis, but a strong, *consolidated* recovery has yet to occur.

Bulgaria's economic growth is highly dependent on exports. Although Bulgarian exports are diverse and include manufacturing goods, services, agriculture products and metals, Bulgaria specialises predominantly in **low-tech production.** Furthermore, its export structure is still biased towards raw materials and primary products rather than high-value-added products and knowledge-intensive services. The domestic private sector comprises mainly of SMEs active in the retail trade sector. Manufacturing industry is oriented towards low-tech goods (EC, 2014).

The domestic private sector's poor technological capacity is a continuing problem, even though the strong contribution from the information and communication (software) sector compensates to some extent for the high share of low-tech manufacturing in fast-growing enterprises (EC, 2014).

Foreign direct investment (FDI) is limited. In 2015, FDI inflows in the non-financial sectors amounted to €23.1bn, which is 7.2% higher than 2014. In 2010-2014, the energy sector in particular, including renewable energy sources, attracted investors' attention, accounting for 25% of FDI. Manufacturing attracted 21% of investment flows, followed by the transport and telecom sectors (16% each). According to the World Bank, the IT industry in particular has experienced robust growth in the last 10 years, with significant FDI among global IT companies (World Bank, 2012).

In contrast to the other C&EE countries, Bulgaria has not yet succeeded in improving its innovation performance and is among the two lowest performers in the Innovation Union Scoreboard 2017 rankings (IUS). It positions the country as a **Modest Innovator**, at the bottom of the EU-28 ranking with Romania.

Demographic developments in Bulgaria hinder the supply of labour. The population is declining, the average age is rising, and regional imbalances are growing. This adverse demographic development is due to both the low birth rate (high mortality rate) and high emigration levels. The mortality rate in Bulgaria is the highest in the EU at 15.3 per thousand. At the end of 2015, the population was 7,153,784 (National Statistical Institute-NSI). People aged 65 and older represent 20.4 % of the population.

2.2 The main challenges in the Bulgarian R&I system

Bulgaria's R&I system faces some serious challenges that urgently require policy intervention. The Bulgarian R&I system is weak mainly because of significant public underfunding of research, shortcomings in the tertiary education system and the decline in research capacity. These factors influence the quality and the applicability of the research undertaken and the capacity to compete in science at the EU and global level.

Table 1, below, lists the main challenges in the Bulgarian R&I system that are relevant to this study and categorises them against a typology of failures in national innovation systems. These failures justify state intervention, not only through research funding, but more widely by ensuring that the innovation system performs as a whole. We describe them in more detail below.

While 'capability failures' amount to inadequacies in any potential innovators' ability to act in their own best interests, 'institutional failures' relate to a failure to (re)configure institutions (i.e. organisations) so that they work effectively within the innovation system. Network failures relate to problems in the interactions among actors in the innovation system, such as poor university-industry links. Framework failures relate to the fact that effective innovation depends partly on regulatory frameworks, such as rulings on IPR, spin-offs etc. as well as on other background conditions, such as the sophistication of consumer demand, culture and social values. (Arnold E. , 2004)

Table 1: Main challenges in the Bulgarian R&I system

Type of failure	Challenges
Capability failures	Decline in research capacity Stagnation in research quality Insufficient research activity in universities Insufficient exploitation of R&D results Insufficient absorptive capacity in the domestic business environment
Institutional failures	Fragmentation of the research system Fragmentation of the HE system Ongoing research-education divide Insufficient co-ordination and integration of research in policy making
Network failures	Barriers for intra-research collaboration Barriers for industry-science collaboration Barriers for internationalisation of research
Framework failures	Little demand for innovation Limited value attributed to research and knowledge creation among politicians and governments

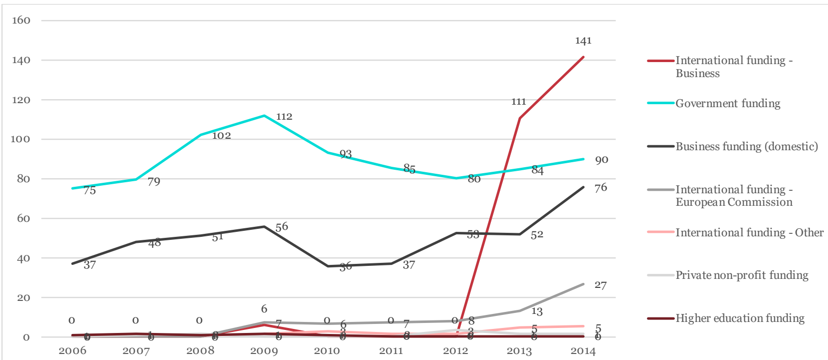
Source: Technopolis Group, based on Eurostat, 2017

2.2.1 Long-term public underfunding of research

Bulgarian gross expenditure on R&D (GERD) is amongst the lowest in the EU28, even though there has been a clear upward trend since 2014. In 2015, GERD accounted for 0.96 % of GDP, compared to 0.6 % in 2012 (Eurostat).

The reason for the recent increase in R&D expenditure is the significant shift in the funding of R&D **from domestic to international sources** (Figure 1). International funding for R&D in Bulgaria (comprising business, European Commission and 'other' funding) totalled €173m in 2014, i.e. 51% of GERD - compared to 4% in 2010. On the other hand, the share of the national government funding of research fell from 43 % in 2010 to 26 % in 2014.

Figure 1: R&D expenditure by source of funds (in m€)



Source: Technopolis Group, based on Eurostat, 2017

The increase in international research funding came in particular from the industry sector. The 2014 RIO report (EC, 2014) indicates that this mainly applied to foreign pharmaceutical companies investing in clinical trials and multinationals active in the field of ICT. In addition, there was also an increase in R&D funding also from European Commission sources.[2] However, Bulgaria's participation in the EC Framework Programme (FP) is limited, however, and current data suggest that its competitiveness is declining. To date, in H2020, Bulgarian researchers have performed worse than the other C&EE countries except for Latvia, both in terms of both the number of participations and EU contributions.

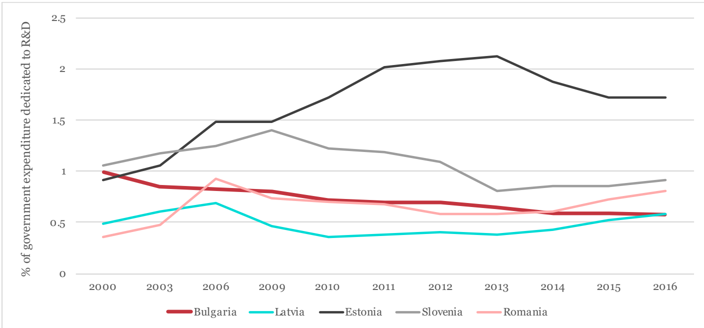
Bulgaria has one of the **lowest R&D intensities** in the EU: in 2014, the Bulgarian government funding of research (GBAORD) amounted to €105.6m, equivalent to 0.25 % of GDP, compared to 0.67 % at the EU-28 level. Only Malta, Romania and Latvia had lower levels (Science Metrix, 2017).

There is an acute – and long-standing - problem related to national public funding for research. For many years, the country's public funding for research has

[2] As considered also in a recent EC study (Reale, 2017), metadata in the Eurostat files are unclear on the extent to which these figures refer only to funding of EU initiatives such as the Framework Programme. It is unclear also under which heading the Structural Funds are included

represented no more than 0.25 % of GDP and was among the lowest in the EU-28[3]. Since 2000, the share of the overall budget that the Bulgarian government allocates to R&D has shown a **continuing downward trend** (Figure 2). While it allocated 1 % of total government expenditure to R&D in the year 2000, the share had dropped to 0.57 % by 2016. In 2000, Bulgaria was among the top countries in the C&EE for its share of government expenditure allocated to R&D; in 2016, it ranked 27th in the EU-28, only ahead of Malta.

Figure 2: Trend in share of government expenditure allocated to R&D



Source: Technopolis Group, based on Eurostat, 2017

As mentioned above, this extremely low level of public funding for research was 'compensated' for by an increase in international funding. The approach to substitute funding from abroad for national funding for research is quite common among C&EE countries. Radosevic and Lepori (2009), however, warn of the risk it entails in creating a **'horizontal' fragmentation in the national R&I system**, opening gaps between research and the local business enterprise sector as well as steering research towards areas of international rather than local relevance. The significant structural changes in thematic R&D expenditure during the 2000-2013 period (EC, 2015) suggest that this is indeed the case in Bulgaria.

- R&D expenditure in the medical sciences increased from 4 to 8 % during the period 2000-2008 and then grew to about 44% in 2011-2013;
- In contrast, R&D expenditure in the agricultural sciences fell from 30% in 2000 to 7% in 2012 and 2013.

R&D in the business sector is highly dependent on funding from abroad, accounting for 67% of the R&D expenditure, while public funding accounts for only 2%. International funding is also important for the HE sector where it accounts for 40% of the funding compared to the government's share of 45% of the funding. R&D expenditure in the government sector depends predominantly on public funding (85% of the R&D expenditure in 2014); funding from abroad accounts for 12%, and funding from the domestic industry for 3%.

[3] Bulgarian GDP in 2015 was €45.3bn with total public funding for research some €113.25m distributed among nearly 150 research facilities, less than 750K per institute.

2.2.2 A fragmented public institutional structure

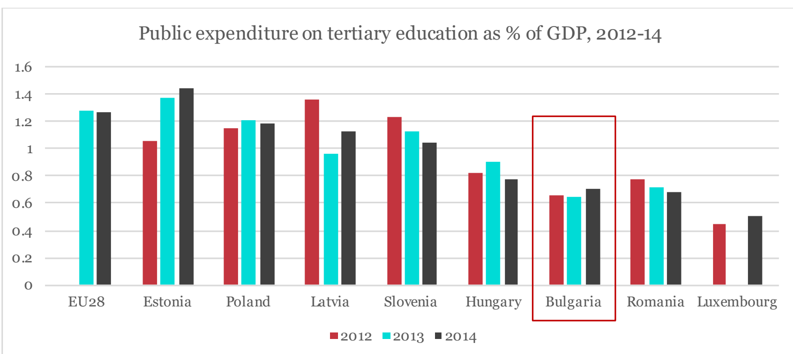
As was noted in the 2015 PSF Peer Review, the Bulgarian research system is characterised by a **particularly high level of institutional density** in the field of research. There are about 120 public research organisations in the country, including 36 public HEIs, 42 Bulgarian Academy of Sciences (BAS) institutes (separate legal entities), 25 Agrarian Academy (AA) institutes, and 18 research institutes acting as 'government labs' providing services to sectoral ministries.

Fragmentation is **most visible in the HE sector**. The country has 51 HEIs, of which 37 are publicly funded. Even when counting only the public HEIs, Eurostat data show that Bulgaria has one of the highest numbers of HEI per unit of population in the EU-28, i.e. one HEI per 190 000 inhabitants, compared to one HEI per 330 000 in Hungary, 350 000 in Romania, 370 000 in the Czech Republic, etc.

The 37 public HEIs range from large multi-disciplinary 'general' universities such as the Sofia University to specialised ones, including 4 medical universities, 4 state/military universities, 3 economic universities, and 12 technical/specialised universities. The 14 private HEI include three multi-disciplinary universities such as the New Bulgarian University and seven HEIs in the field of economics (business schools). Many university professors teach in more than one university.

The HE system is **significantly underfunded** from the public purse. Public expenditure on tertiary education in Bulgaria is among the lowest in the EU. In 2014, it accounted for 0.7% of GDP, as against an EU-28 average of 1.27% (Figure 3, below). It placed Bulgaria in 26th place among the EU28 Member States, at a level equal with Romania and higher only than Luxembourg. This institutional funding covers more or less only the personnel costs. According to Eurostat, the total public expenditure on tertiary education was €380.6m in 2014, i.e. on average about €10m per public HEI. In that same year, personnel costs for the public HEIs totalled 97% of this sum.

Figure 3: Public expenditure on tertiary education as % of GDP



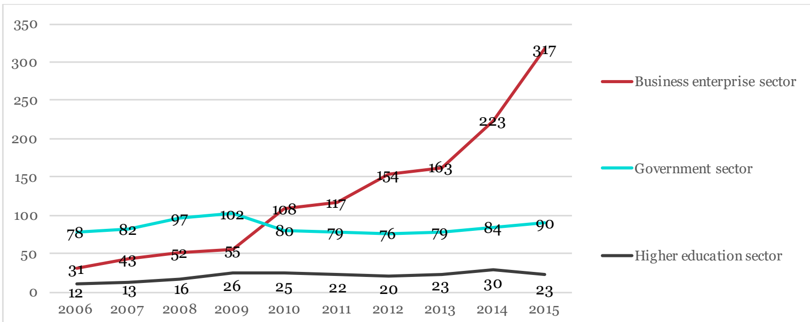
Source: Technopolis Group, based on Eurostat, 2017

2.2.3 A research gap in the HE system

The data on trends in R&D spending per performance sector (Figure 4, below) show considerable differences among the three main actors in the Bulgarian R&I system. There was a significant increase in business R&D expenditure from 2014 onwards, spurred by investments from foreign private enterprises, and research investments in the government sector - i.e. the public research institutes, -are making a slow recovery from the considerable drop in 2010.

The HE sector shows a **persistently low level of research activity**. In terms of share of GDP, it was at the lowest level in the EU in 2015 (0.05 %) and remains in continuous decline (EC, 2017).

Figure 4: Trend in R&D expenditure in the research-performing sectors, in m€



Source: Technopolis Group, based on Eurostat, 2017

Major barriers for research in the HEIs are the underfunding of the HEW system as such (see Section 2.2.2, above) and the ongoing perception of a research/education divide. The remains of the binary academy/universities model from central planning combined with developments in the research and HE system in the 1990s have created an artificial **separation of research from HE.** It has led to continuing difficulties in overcoming the perception of universities as purely educational structures – among university management, policymakers and industry actors.

The general approach of HEI management is to maximise the academic staff's teaching time to save on costs. The insufficient level of financial support also negatively affects the conditions for scientific research, including academic staff salaries and the maintenance of facilities, equipment and research infrastructure. (EC, 2010). Only a small number of HEIs have and manage adequate research facilities, mainly thanks to EU and other donor programmes (Todorova, 2015).

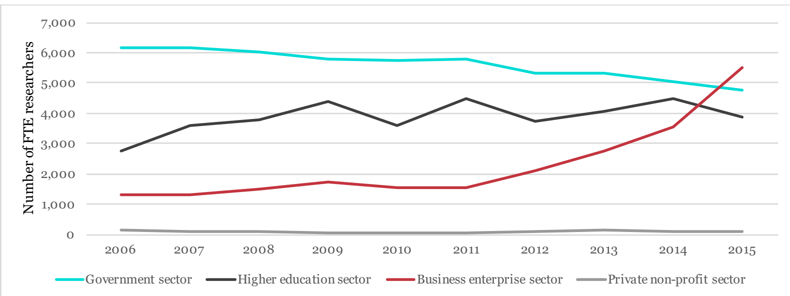
2.2.4 A limited research capacity

In a European context, Bulgaria has a **relatively low level of FTE researchers**. Adjusting the FTE researcher data using the size of the active workforce in the countries, Bulgaria ranks 23rd among the EU-28 Member States with 0.68 FTE researchers per 1,000 active workforce, as against an EU-28 average of 1.2 FTE researchers (Eurostat, 2017). Taking into account only those researchers *employed in the government and HE sectors*, Bulgaria ranks 24th in the EU landscape, with 1.21 FTE researchers per 1,000 inhabitants versus an EU-28 average of 1.92.

Since 2006, and particularly in recent years, the trend in researcher employment in Bulgaria shows diverging trends in the three main sectors involved (Figure 5, below). In the last 10 years, there has been a growing number of researchers employed by industry and in the public HE sector. In this context it should be noted that in Bulgaria, every academic staff member is considered a researcher.

In contrast to the business and HE sector, researcher employment has been **in continuous decline in the government sector**, especially in the fields of engineering and technology and medical and health research where the number of FTE researchers in 2014 was that in 2006. Eurostat data suggest that the development in the engineering and technology field benefitted the business sector rather than the HEIs. In 2016, the Ministry of Agriculture reported that since 2000, the number of scientists in the Agricultural Academy had fallen by 49%, and the reduction is still ongoing (Ministry of Agriculture and Food, 2016).

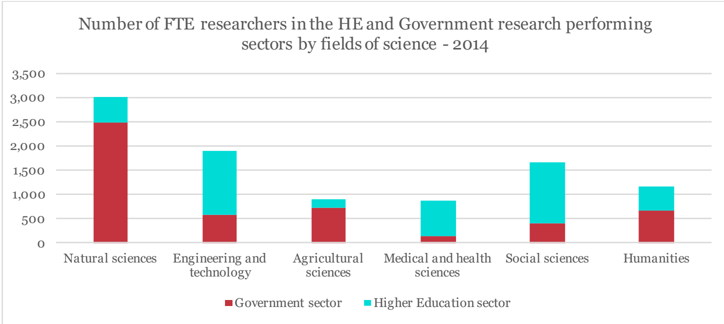
Figure 5: Trend in number of FTE researchers by sector, 2006 - 2015



Source: Technopolis Group, based on Eurostat, 2017

There is a **'scientific division of labour'** between the research institutes in the government sector and the HE sector (Figure 6, below). Based on Eurostat data for 2014, researchers employed in the government sector have a strong presence in the natural and agricultural sciences; public HE researchers make up for the highest share of FTE researchers in the medical and health sciences, engineering and technology, and the social sciences.

Figure 6: FTE researchers in the HE and government systems by fields of science (2014)



Source: Technopolis Group, based on Eurostat, 2017

The 2017 National Strategy states that Bulgaria is among the leading EU countries in terms of gender equilibrium among research staff. Based on NSI data of 2015, the strategy paper also considers that there is a balanced age distribution among researchers (up to 34 years: 21%; 35-44 years: 27%; 45-54 years: 23%; 55 – 64 years: 24%; 65+ years: 5%).

Thus, the major issue concerns the capacity to **retain experienced scientists** in Bulgaria and to **attract (and retain) young talent**. In this context, brain drain is a major problem. Bulgaria has been experiencing massive outflows of highly skilled people, including researchers. In the World Economic Forum (WEF) Global Competitiveness Report 2013-2014, it ranked among the countries with the lowest capacity to both retain (142nd out of 148) and attract (144th) talent. (EC, 2017).

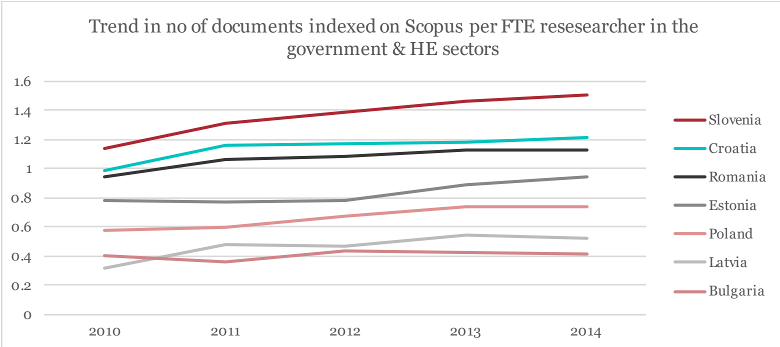
The National Strategy for Research, adopted in 2017, refers to various reports that indicate in scientists' low salaries and low social status in Bulgaria one of the main causes of the migration of young researchers and the low attraction of scientific careers. In 2016, the average base salaries for a professor, associate professor and chief assistant in BAS accounted for 79%, 67% and 55% (respectively) of the average salary in the country. As of the beginning of 2017, scholarships for PhD students remain below the minimum salary.

Nevertheless, Eurostat data suggest that in contrast to most other C&EE countries, Bulgaria seems to have succeeded recently in reversing the declining trend in the number of PhD students. In 2015, it had a total of 6,617 PhD students, i.e. 0.9 doctoral students per 1,000 inhabitants, compared to 0.7 in 2013. For this indicator, Bulgaria ranked 23rd among the EU28 Member States in 2015, ahead of Croatia, Hungary, Spain, Italy and Malta.

2.2.5 Stagnation in research performance

Bulgaria is **one of the weaker research performers** in the EU28. Our analysis of documents indexed in Scopus shows that the country has one of the lowest rates of production of scientific documents per FTE researcher employed in the government and HE sectors in the EU28 (Figure 7). Most important, it has remained **close-to-stable** in the last five years, while an upward trend can be seen in all other comparator countries.

Figure 7: Number of documents indexed on Scopus per FTE researcher

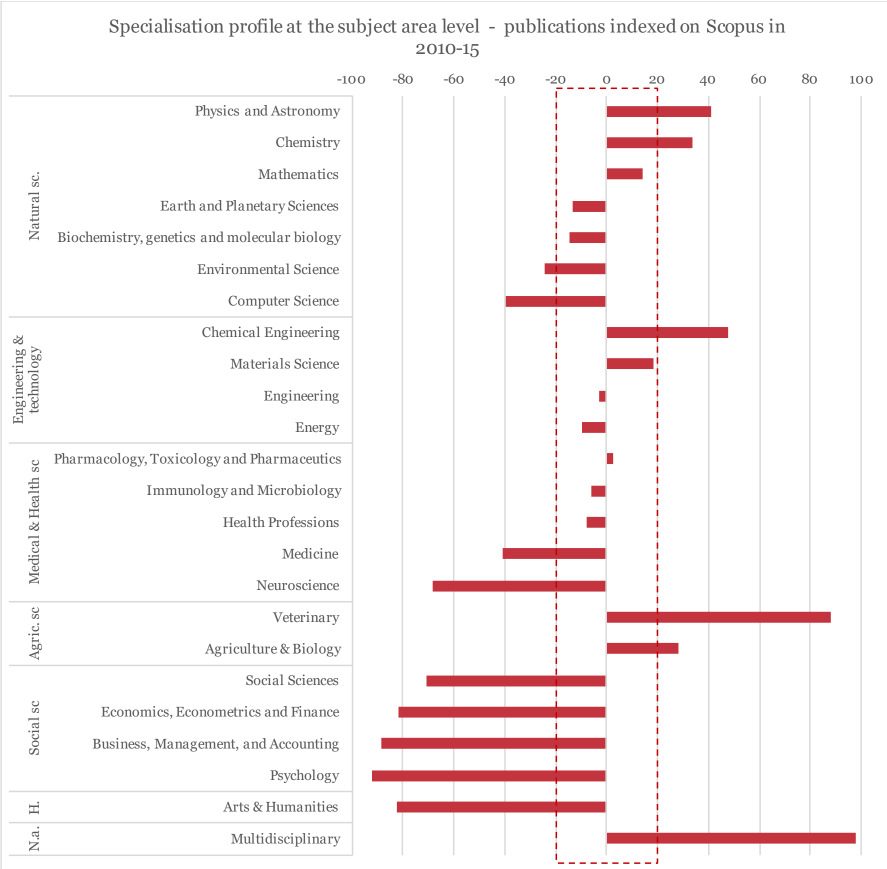


Source: Technopolis Group analysis, based on SCImago Journal and country ranks; Notes: documents indexed on Scopus include articles, books, chapters, conference papers, editorials, errata, letters, notes, reviews and short surveys

The bibliometric analysis that was conducted for this study, based on Scopus data, showed that medicine, physics and astronomy, engineering, and agrarian science and biology are the disciplines with the highest number of scientific publications indexed in Scopus. Considering that these data are influenced by the different publication propensities among the subject areas, we field-normalised the publication counts for the period 2010-15, thereby defining the **specialisation profile** of Bulgarian research, based on numbers of publications (Figure 8, below). The analysis shows that when considering publications in the international sphere:

- Bulgarian research stands out compared to the EU28 average in the subject areas of multidisciplinary research, veterinary sciences, chemical engineering, physics and astronomy, chemistry, and agriculture and biology (values above 20).
- The under-specialisation of Bulgarian research (values below -20) is particularly strong in the social sciences and arts and humanities; it is also remarkable in the neurosciences, and to a lesser extent, in the medicine, computer science and environmental science subject areas.
- In the other subject areas, Bulgarian research positions itself in the EU-28 average (values between -20 and +20); mathematics and material sciences appear to be promising areas for future specialisation.

Figure 8: Specialisation profile at the subject area level – based on number of publications



Source: Technopolis Group elaboration, based on Scopus Notes: Specialisation indices are calculated based on the relative weight of the peer reviewed publications and reviews of the country (in this case, Bulgaria) compared to the weight in the EU-28 with transformations applied to the measure in order to centre the indices around zero and fix their range between -100 and 100 (based on logarithmic and hyperbolic tangent functions). Large positive (resp. negative) values illustrate high (low) specialisation in the subject area

2.2.6 Poor interaction between HE, research, and innovation

Knowledge circulation between and among universities, research institutes and the business sector is a major challenge. The deficit in knowledge exchange and cooperation is visible at various levels.

The malfunctioning of the research-teaching component of the 'knowledge triangle' challenges both the quality of education and expansion of the country's research capital and capacity.

Knowledge exchange between universities and the research institutes of BAS and AA predominantly occurs in the context of PhD education, and at an individual informal level through teaching activities in the universities by scientists employed in the BAS or AA institutes. Strategic long-term partnerships between universities and BAS/AA research institutes are rare. The 'public research centres' and ‘competence centres’ that are currently planned under the ESIF (EU Structural and Investment Funds) are among the first coordinated initiatives to foster collaboration between research institutes and universities.

Research-industry links are impeded by the lack of a critical mass in research-performing industrial actors in the country and the **low technological absorptive capacity** of the domestic private sector, as mentioned in Section 2.1, above.

Intellectual assets are a strength in Bulgaria in terms of **trademark and design applications**. However, Bulgaria still performs far below the EU average in terms of PCT patent applications (EC, 2017). The World Bank (2012) shows that Bulgaria has experienced a significant reduction in the number of innovations protected by patents since 1990, especially in mature fields related to its traditional industries, such as the mechanical, electrical and electronic, chemical, computers and communications, and drugs and medical sectors (in order of importance based on 1981-1990 patent applications). At the beginning of the current decade, however, the declining trend was reversed. According to the World Bank, most new patents granted to Bulgarians by the United States Patent and Trademark Office (USPTO) are related to high-tech industries, especially computers and communications.

2.2.7 Discontinuity in the policy decisions and the issue of trust

One of the key findings of the H2020 PSF Peer Review was the lack of consensus in society, business, and parliament on the key role of scientific research for the country’s socio-economic development. (EC, 2015) This sets the background for the government’s low – and declining - prioritisation of knowledge creation in general. The 2017 EC European Semester Country Report, for example, mentions that while Structural Funds are an important source of funding for R&I activities in all C&EE countries, in Bulgaria only €293m of the €6.7bn of Structural Funds in the 2007-2013 programming period were spent on R&I, i.e. 4.4% of the total, which is the lowest share in the EU. This is also reflected in the particularly low level of researcher salaries.

A further and persistent characteristic of the Bulgarian research governance system is the uncertain duration of policy and strategies, creating a lack of trust in the system among the research community. The 2015 Research and Innovation Observatory (RIO) report (EC, 2015) noted that the Bulgarian R&I system appears over-regulated due to a lack of systemic trust while, at the same time, policymaking is often divisive, volatile and unable to survive governmental changes. The authors considered that while current legislation mirrors the good intentions of many consecutive governments to make decisions more objective and transparent by creating a strong legal base, the high legislative output may be counter-productive and may support systemic inertia. They noted that anecdotal evidence given to the PSF panel seemed to suggest a growing weakness and unpredictability in the system due to a considerable turnover of fragmented legal initiatives and incomplete implementation of legal acts. The laws and regulations might be approved but may have a low level of both institutionalisation and irreversibility.

The uncertain duration of policies and strategies is a persistent characteristic of the Bulgarian research governance system. Numerous national policy papers and strategies adopted by the parliament, which set out principles – and in certain cases, targets and commitments – see only limited or even no implementation. A prime example is the public funding of research. Repeatedly in the past, Bulgarian governments have set targets that were subsequently revised downwards. In 2014, the national strategy (MES, 2014) set the target for the public R&D expenditure in 2020 at "at least" 0.6% of GDP; in 2016, the new national strategy (MES, 2016) revised this target for 2020 down to 0.45% of GDP and set a target of 0.67% of GDP for 2025; in 2017, the revised national strategy (MES, 2017) set the target for 2020 at 0.50% of GDP and at 1.00% of GDP for 2025. The target for 2018 is to reach a public investment in R&D equal to 0.38% of GDP in 2018; the actual and rather constant figure in recent years is 0.25% of GDP.

2.3 The current research evaluation and funding system

We start this section with a description of the current public research funding system, including the role and position of performance-based funding for research. We summarise the National Strategy for research which aims to reform the Bulgarian research system, and cover the proposed categorisation of the HEIs in the national strategy for the HE sector. We conclude this section with a description of the current national methodology for the evaluation of research, defined in the 2015 Regulations, and briefly describe the outcomes of the pilot evaluations conducted in 2016 and 2017.

2.3.1 The current public research funding system

Like most countries, Bulgaria has a **'dual-support' system for research**, i.e. competitive (project) funding and institutional funding.

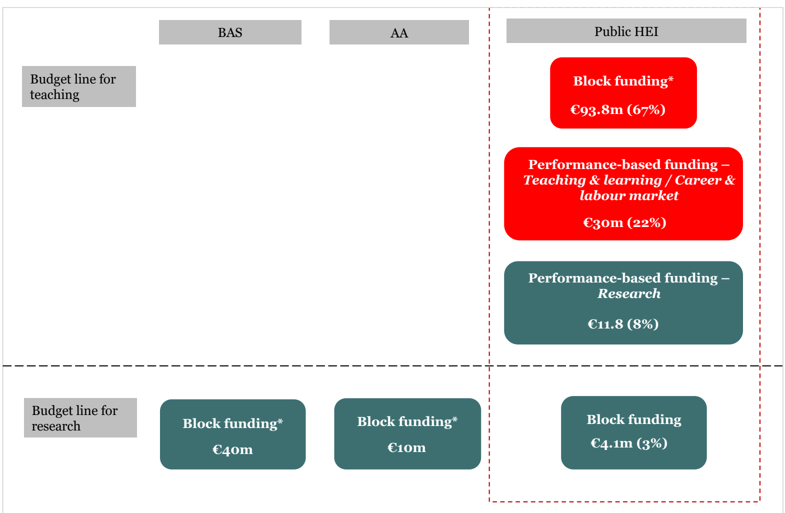
In relation to the **institutional funding for research**, different models apply for the research institutes and the public HEIs (see Figure 9, below).

- The research institutes receive block funding, which_includes funding for infrastructure, equipment, salaries etc. Different rules for the budget definition apply for:
  - The *Academy of Sciences (BAS)*, for which the amount of institutional funding is defined annually by the parliament in the Budget Law; the Ministry of Education and Science (MES) acts as an intermediary without supervisory power. After a sharp cut in its budget by roughly 40% in 2010 (EC, 2010), institutional funding for BAS has shown a slight increase in recent years. In 2017, it amounted to €40m
  - The *Agricultural Academy (AA)* is funded from the state budget through the Ministry of Agriculture and Food (MAF); however, it is under the dual control of MES and MAF. Information on AA institutional funding is extremely limited; its budget for 2017 was *estimated* by the MES to be €10m

- In the case of the public HEI, institutional funding for research is a component of the *overall* institutional funding. Based on data provided by the MES, in 2017, the total institutional funding budget for HEIs was about €140m (BGN 274m), i.e. €3.9m average per public HEI. The budget comprises three components; in all three components, the size of the HEI is defined in terms of number of students.
  - *Block funding for the educational activities*, which accounts for 67% of the institutional funding, i.e. €93.8m in 2017. This funding covers infrastructure, equipment, salaries, etc.
  - A *performance-based funding component* was launched for the public HEI in 2016, aiming to improve the quality of tertiary education in the country and, in particular, better alignment of the educational programmes with the needs for economy. In 2017, it accounted for 30% of the HEI institutional funding. There are three criteria, one which relates to HEI performance in research that accounts for 28% of the performance-based funding component.[4] Thus, in 2017, the *performance-based funding for research* in HEIs amounted to €11.8m
  - By law, HEI institutional funding should also entail a minimum 10% earmarked for conducting research. However, this is subject to a ministerial decision by the MES. In 2017, HEIs received *block funding for research* amounting to €4m (BGN 8m), i.e. 2.9% of the total institutional funding for the public HEIs

Therefore, overall, the HEIs' institutional funding for research amounted to about €16m or 11% of their total institutional funding, 75% of which was performance-based.

Figure 9: The current institutional funding system in Bulgaria – funding for 2017



Notes: *Includes funding for infrastructure, systems, salaries etc. Source: Technopolis Group, based on MES data (June 2017)

[4] For the HEI in the field of Arts, the research component is not counted for

There are three main sources for **competitive funding** of research.

- The National Science Fund (NSF), managed by the MES, is in charge of the national competitive funding for research. The NSF funds both basic and applied research as well as training for public-sector institutions. It provides financial support based on programmes and projects, allocating about 30% of its resources to funding projects by young researchers. In 2016, the funding available was €9m; in 2017, it was €10m
- ESIF Operational Programme funding for 2014-2020 dedicated to R&I amounts in total at €581.6m; 85% of this budget (€494m) derives from EU funding through the European Regional Development Fund (ERDF). About half of this budget is dedicated to supporting public research (the Priority Axis "Research and Technological Development" in the Operational Programme Science and Education for Smart Growth). However, only 60% of this Priority Axis budget has been earmarked yet, specifically for the creation and development of Centres of Competence and Centres of Excellence. In other words, so far (only) €171.8m has effectively been allocated to support the public research system in 2014-2020, of which €22.8m is national contribution (an average of €3.5m a year) and €149m is EU funding (an average of €21.3m a year)
- A final source of funding are the EU research funding programmes such as COST and the FP. As for Bulgarian participation in the EC FPs, H2020 monitoring data indicate a funding of €12.3m in 2014 and €10m in 2015. (EC, 2016)

The above shows that EU funding - through the Operational Programmes and the Framework Programme - is the main source for the funding of competitive research in Bulgaria, accounting in total for close to three times the total national competitive funding.

National competitive funding accounts for 13% of the total national public funding for research. Table 2, below, gives the breakdown of the current annual public budget for research in competitive versus institutional funding.[5] It is based on data provided by MES.

Table 2: Annual public funding for research in public research institutions (estimate; 2017)

Research budget	Annual budget in €m	Share in funding
National competitive funding for R&D	**10**	**13%**
NSF	8	11%
Young Scientists programme (NSF/BAS)	2	3%
Institutional funding for research	**65.9**	**87%**
BAS – block funding	40	53%

[5] Details on institutional funding for research allocated to the state and military HEI as well as the government labs were not available

Research budget	Annual budget in €m	Share in funding
AA – block funding	10*	13%
HEI - institutional block funding for research	4.1	5%
HEI – performance-based funding for research	11.8	16%
Total public funding for research	**93.5**	**75.9**
		100%

Source: Technopolis Group, based on MES data (June 2017)

2.3.2 The national strategy for research

The *National strategy for development of scientific research in the Republic of Bulgaria 2017 – 2030: Better science for better Bulgaria* (referred to as: '2017 National Strategy'), adopted by the parliament in 2017, is the **main overarching policy document on research** which defines the basis for future developments. It followed – and adapted - the National Strategy that was adopted in 2016.

The policy paper outlines the major objectives for research in Bulgaria and defines the key instruments needed to achieve these objectives in the medium- and long-term, establishing a **strong correlation between funding and research results**.

The long-term aim is "to achieve long-term economic growth and to significantly improve the quality of life in the country". Its main objectives are "to reach a scaled, rapid and long-term development of the research system in Bulgaria so that it becomes an attractive centre for advanced research and development of new technologies; to recover and raise the international prestige of the country in science; and to retain and attract talented scientists in Bulgaria."

These policy objectives are to be reached by applying a set of interrelated and complementary policies affecting one or several components of research, for which specific objectives are formulated and activities defined – as shown in Table 3. There are also three 'horizontal' activities: increasing public funding for research; synchronised changes in legislation related to implementation of the strategy; and reform of the management and administration structures, related to research.

Some of the concepts for the future performance-based funding system are described under the *'Policy for development of human potential'*, highlighting the importance of **ensuring a critical mass in research**, and specifically "motivated and highly qualified researchers". This sets the background for the concept of a differentiated remuneration for researchers at an individual level, "directly related to the scientific results achieved", and therefore a **periodic assessment of the individual researcher**, done at the central level. The aim is to achieve the EU's average level for the number of researchers.

The objectives and approach for the evaluation at institutional level are described under Activity 1.2. In the first instance, the importance of evaluation to **inform the government** on the effectiveness of the research policy is highlighted, as well as the importance of **rewarding excellence** ("In order to achieve high scientific results, it is necessary to stimulate those teams that conduct high quality research". […] It is important to map the scientific achievements of the universities and research institutes and the best of them to be stimulated by the state.")

Of equal importance for the characteristics of the future PRFS is the "**Policy for the development of fundamental research and stimulating excellent science**" section. The policy objective is to support the development of world-class fundamental research by applying "internationally recognised standards for assessing scientific results". The qualitative and quantitative results from fundamental research will be used as criteria for assessing the research organisations and universities and their units and as an indicator for implementing this programme.

Table 3: Policies and specific objectives in the 2017 National Strategy

Policy	Specific objectives
Policy for development of human potential	**Specific objective 1**. Providing high qualification and effective career development for researchers, based on high-level research.
	Specific objective 2. Increase of the living standard and the social status of the researchers and specialists engaged in research activities by ensuring adequate payment related to the results accomplished as well as good working conditions
	Specific objective 3. Increase in the number of researchers to typical EU levels and their balanced distribution by age, gender, scientific fields and regions
	Specific objective 4. Development, maintenance and effective use of modern scientific infrastructure, balanced across thematic areas and regions, and providing the necessary access to European and international scientific infrastructure
Policy for the development of fundamental research and stimulating excellence science	**Specific objective 5.** Sustainable recovery of the country's international positions concerning the quantity and quality of internationally visible scientific production up to and beyond the level typical for the beginning of the century
	Specific objective 6. Raising the quantity and quality of research related to issues of national importance
Policy to stimulate applied research	**Specific objective 7.** Promoting the applied research and focusing them on the priority areas of the Innovation Strategy for Smart Specialisation ISSS.
	Specific objective 8. Stimulating the private research investments.
Integration policy in the European Research Area and expansion of the international	**Specific objective 9.** Deepening the integration of the Bulgarian scientific community in the ERA and expanding international scientific cooperation.
	Specific objective 10. Significant intensification of links between science and education, businesses, governments and society as a whole

Policy	Specific objectives
scientific cooperation	

The strategy defines different stages of development, from a recovery stage (2017-2022) to accelerated development (2023-2026) and finally to research at global level (2037-2030). Linked to these 'development stages' is a **gradual, annual increase in direct R&D funding** from the state budget, reaching 0.38% of GDP in 2018, 0.50% of GDP in 2020 and 1% in 2025.

The strategy foresees the following evaluation and performance-based funding 'modules'.

- **Incentives** by means of (additional) earmarked funds for publications in international scientific journals, for a limited period of time
- A **"periodic attestation"** to monitor and assess research performance of the institutions, research teams and individual researchers. The best of these should be rewarded – by higher salaries for individual researchers. In the case of research units or organisations, a negative result of the attestation would imply reduction or discontinuation of the funding, while individual researchers would no longer be allowed to occupy an academic position after more than one negative attestation evaluation
- An **independent international evaluation** of the 'scientific organisations', "according to the established international practices and the accumulated experience of the European Commission bodies." Scientific organisations that will be included in the international evaluation are the institutes of the Bulgarian Academy of Science and Agricultural Academy, the scientific institutes in ministries and departments, and the *research* universities. No further details on the evaluation methodology for this international panel evaluation are provided

The strategy also considers **research evaluation criteria and focus areas**. It emphasises the importance of research that is of societal and cultural importance and recommends the use of relevant databases and sources to monitor the production of such research and the development of adequate quantitative criteria for their inclusion in the evaluation exercises. No specific plans are put forward. It also suggests the inclusion of quantitative indicators related to applied research in the monitoring and evaluation exercises. Lastly, the strategy emphasises the promotion of international collaboration and its inclusion in institutional evaluation, as well as the need for a system to award additional institutional funding, detached from the institutional funding for education, to universities of internationally recognised scientific excellence.

While the 2017 National Strategy therefore covers the expectations related to the performance assessments in sufficient detail, specific indications on **the PRFS funding component** are still missing. No decisions have been taken, for example, on the amount of research funding that will be performance-based or the shape of the funding formula.

2.3.3 Policy reform in the HE sector

As regards the reform of the HE sector, an aspect of particular interest to this study is the **categorisation of HEIs** that was proposed in the Higher Education Strategy, adopted by Parliament in 2015 (MES, 2014). The strategy paper emphasised the need for a clearer distinction between universities and specialised HEIs "that only train students in one or several related professional fields (e.g. technical, medical, arts, etc.)" as well as the need to distinguish between two types of HEI "according to their research activity".

No specific definition of a **'research university'** was provided; the description is one of a university that has a strong scientific output and makes a significant contribution to the development in important societal areas through cutting-edge research and high-quality research results. These qualities would be judged though science metrics such as patents and articles in indexed scientific journals. Only research universities would be allowed to train PhD students.

'Research universities' would be entitled to funding for research from the national budget, but "will be required to report to the state and society on the effectiveness of the funds spent on science (e.g. this will be part of their accreditation assessment)." Measures proposed in the HE strategy included a performance-based funding for research and the introduction of thresholds for the institutional funding of research, based on the quality of the research ("cancellation of subsidy for scientific activities in HEI with low scientific outcomes").

The National Strategy for Research, adopted in 2017, picks up on the concept of 'research university' and indicates that these HEIs are the ones for which the PRFS – and its related (additional) funding – would apply.

However, the Amendment to the Higher Education Act ,that was adopted in 2016, defined only three types of HEIs (Article 17): universities, specialised HEIs, and independent colleges. There is no specific mentioning of the status of a 'research university'; **all** HEIs are expected to conduct research.

- A 'university' provides training in a wide range of subjects in professional areas within at least three of the four major branches of science (humanities, natural sciences, social sciences and technical sciences). It offers courses at all levels, including PhD
- A specialised higher school conducts scientific research or artistic and creative activities and offers courses of training in one of the major areas of science, arts, physical culture, and military science; it *may* include courses at PhD level
- A 'self-contained college' shall provide instruction for the Bachelor's educational and qualification degree; a college may be established also within the structure of a university or of a specialised higher school

2.3.4 The current research evaluation methodology

In 2015, the considerable dissatisfaction and mistrust in the competences of the National Science Fund, combined with the trend towards performance-based funding systems, led to the publication of the 'Regulations on the monitoring and evaluation of research activities performed by higher education institutions and science organisations, as well as the activities of the National Science Fund' (to be referred to as the 2015 Regulations).

The national methodology for the evaluation of research that is set out in the 2015 Regulations is currently being piloted and constitutes the basis for the **evaluation component of the future PRFS**; it has also partly defined the assessment criterion related to the scientific research activity in the performance-based funding system for the public HEIs.

The key objective of the national research evaluation methodology, defined in the 2015 Regulations, is to improve the quality of research by introducing "international quality standards". Specific objectives include:

- To evaluate research organisations' activities and analyse their positioning in the European and global research area
- To identify and support research activities that have a proven potential of national significance and/or international recognition
- To stimulate organisations to reach high, internationally recognised results for research activities, based on a system of objective, measurable and transparent evaluation criteria
- To ensure transparency in the implementation of the national research policy and research funding

The 2015 Regulations established that evaluation of research organisations would be purely metrics-based and take place annually, covering all scientific disciplines and overseen by an independent committee comprising a chair and 12 members.

The '**unit of analysis'** is the faculty in the HEI or research institute in the academies (BAS and AA). These units are categorised (and grouped in the case of the universities) according to a disciplinary classification defining the six scientific areas in which the units of analysis compete. In the 2017 pilot evaluation, these six disciplinary areas were reorganised, and 10 scientific areas were used (Table 4). All individual researchers are included in the evaluation.

Table 4: Revised categorisation of the scientific areas

Scientific areas as per Regulation	Scientific areas used in the 2017 evaluation
Liberal sciences and arts	Human and Social Sciences (including law and arts)
Social, business, and legal sciences	Economics (including business management
Natural sciences, mathematics, and informatics	Life sciences and biotechnology Physical sciences and technologies

Scientific areas as per Regulation	Scientific areas used in the 2017 evaluation
	Chemical sciences and technologies Geological and crystallographic sciences Mathematics, informatics, information and communication technologies
Technical sciences	Architectural, engineering, and construction science and technology
Agricultural sciences & veterinary medicine	Agrotechnology Agrosciences, veterinary medicine
Healthcare and sport	Medical sciences, health care and pharmacy

There are **17 indicators** grouped into **three assessment criteria**: research results, research capacity, and national and international distinction (Table 5).

Table 5: List of evaluation criteria and indicators

Criterion	Indications
Research results	• **Productivity** - two indicators: scientific publications and monographs • **Citations** - four indicators: number of citations, two indicators related to journal impact factors (number of articles in general and one of number articles in top 10% JIF journals), and one to the h-index • **Patents** - three indicators: number of patent applications, awarded patents, and patents related to contracts with industry
Research capacity	• **Research staff** - three indicators: related to the characteristics of the research staff in terms of academic titles • **External funding** - three indicators: national or international projects and programmes, and contract research by industry • **PhD education** – one indicator: PhDs awarded
National and international distinction	• **Esteem** of the research organisation or its individual members – three indicators: membership of editorial boards, of scientific networks and/or of scientific companies

The 2015 Regulations also define two fundamental elements of the PRFS funding component, i.e. the **volume measures** and the formulae for the definition of the **final scores** that inform the ranking of the research organisations - and ultimately, the funding allocations.

Five final ranking categories are defined through an algorithm based upon the Lorenz curve.

- Group 1 — elite; these include no more than 10 to 15 % of the organisations in the scientific area
- Group 2 — effective organisations
- Group 3 — satisfactory; organisations performing scientific work effectively
- Group 4 — organisations with insufficient effectiveness
- Group 5 — organisations with weak efficiency, in need of methodological assistance to improve efficiency

The Ministry of Education and Science launched pilot evaluations in 2016 and in 2017. The 2017 pilot evaluation involved 108 research organisations, including 41 BAS institutes (out of 47), 16 AA institutes (out of 25), 35 public HEI (2 state HEI were not involved), 8 private HEI (out of the 14), 4 (medical) government labs, and 2 hospitals. It involved 288 'units of analysis', but the evaluation report mentioned that 67 of these could not be assessed because of missing data and/or because the size of research staff was below the (apparently established) threshold level of 10 members.

The **221 'units of analysis'** were subdivided into scientific areas. The highest number of units was in the field of human and social Ssiences (54 units), concentrated in the public HEis; the smallest number was in the geological and crystallographic sciences area (3 units). A third of the public HEIs involved (12 out of 35) registered only one unit of analysis; these were predominantly the technical universities, including the Technical University of Sofia.

Based on the current evaluation methodology, approximately 60% of the assessed units of analysis conducted research in at least a satisfactory manner (Table 6). This included all institutes in the BAS, 80% of the institutes assessed in the AA, and about 75% of the units of analysis in the public HEIs (excluding the three state HEIs).

Table 6: Units of analysis ranked in categories 1, 2 or 3

Sector	Units of analysis assessed	No of units in categories 1, 2 or 3
AA	16	13
BAS	41	41
Public HEI	145	108
Private HEI	9	7
State HEI	4	3
GovLab	4	3
Hospital	2	1
Total	**288**	**176**

Source: Technopolis Group, based on the 2017 Pilot Evaluation report

3 CONDITIONS FOR AN EFFECTIVE PRFS

Performance-based funding systems are important **policy instruments** for the governance of research. They provide R&I policymakers with the opportunity to address the major failures in their national R&I system while recognising the autonomy of the research-performing organisations in deciding on their institutional strategies and management practices.

PRFS are intended to *complement* other policy instruments. They are not stand-alone systems. The **interaction** between the PRFS and the other policy instruments for the governance of research defines the degree of influence the PRFS may have on the way the country conducts research.

Thus, the introduction of a performance-based research funding system in Bulgaria must be **put in the context** of Bulgaria's overall R&I governance system.

3.1 The function of the PRFS in the research governance system

3.1.1 Context

The 2017 National Strategy concludes its analysis of the state of scientific research in Bulgaria with the statement

> *"The damages that have been caused during the last decades on the state of the science and as a consequence, on the entire country, are very serious and hard to reverse. New delays in taking urgent measures in the research and development sector will result in a serious risk for a lasting lagging behind of Bulgaria, both in its economic growth and in the quality of life."*

We fully agree and see an urgent need for immediate measures to address the most pressing issue for the Bulgarian research system, i.e. **the dispersion of the already minimal national institutional funding for research**. As was also mentioned in the Recommendation 2.5 of the 2015 Peer Review addressing the need for performance-based funding for PROs, the model for funding Bulgarian HE and research organisations must be revised.

This need for an improved funding model, however, has its roots in the **most fundamental failure** of the Bulgarian R&I system, i.e. its **significant fragmentation**. Measures addressing this failure are critical to reverse the current decline in Bulgaria's research capacity and boost the value of the country's research for the education and industry sectors, and society at large.

Fragmentation in the R&I system is a long-term issue in Bulgaria, dating back to the beginning of the post-socialist era. It relates in particular to what Dobbins called the "situation of unfettered autonomy" in the early 1990s (Dobbins, 2007) when faculties and units in public universities gained independence, combined in later years with the closure of research institutes which were turned into faculties or universities. The result was an increase in the number of public universities from five at the end of the 1980s to the current 36. As mentioned in Section

2.2.2, above, fragmentation of the research system is primarily an issue in the HE sector.

Since the mid-1990s, attempts made by the MES to draw up a coherent reform package in the HE sector and bring the system in line with modern European standards have included initiatives that addressed the structure of the HE system in a more direct way (Popov, 2000). This failed due to a number of reasons, including the ministry having difficulties in defining its role in setting HE policy, opposition in academia to what was felt to be the re-emergence of 'state control', combined with strong vested interests and reluctance to change. Political discontinuity because of the frequently shifting governmental coalitions and weak administrative capacity at both state and university level also played their roles (Dobbins, 2007)

3.1.2 The role and function of the PRFS

The current design of the PRFS in Bulgaria is perceived purely as a **funding instrument** and not as a tool for strategic R&I governance, which a PRFS is intended to be. We see no consideration of the important systemic effects that PRFS may induce or how the use of specific indicators might stimulate a change in behaviour to address the many failures in the R&I system, beyond the general 'conduct of research at international level'[6]. To summarise, its main – if not only – function is to address the low level of institutional funding for research in the country's individual institutions (both 'academies' and HEIs) by concentrating such funding on those organisations that show good research performance – and especially by rewarding those carrying out excellent research.

The current PRFS should be put in the context of the recent government strategy (summarised in Section 2.3.2, above) which suggests that Bulgaria is adopting a **policy of 'passive adoption' for the structural reform** of the R&I system, i.e. relying on changes in the funding system (the PRFS) and other indirect measures for a **gradual change**, rather than trying to actively restructure the system. (Radosevic & Lepori, 2009).

However, the **gravity of the current challenges** in the Bulgarian R&I system and the extent to which fragmentation is embedded in the cultural and political environment, as set out above, lead us to consider that a 'passive' or 'indirect' restructuring of the Bulgarian research system is **not a viable option**.

Most important, while a PRFS could be a key component of a policy intervention addressing the necessary restructuring of the R&I system, it is unlikely to solve the various inefficiencies, overlaps and systemic failures in Bulgaria's research system – even if its design were to be drastically improved. A performance-based research funding system can be of little value if it is implemented in a research system that is fragmented to such a level as that of Bulgaria today. In other words, unless the PRFS is **combined with a structural reform**, it cannot be expected to help overcome research fragmentation.

[6] We cover the objectives of the PRFS in greater detail in the next chapter.

We therefore believe that a **structural reform of the Bulgarian R&I system is an absolute precondition for any PRFS to be effective.**

In our view, achieving the essential minimum-scale conditions for research, reaping synergies and scale advantages across both disciplines and institutions, is essential for the successful introduction of a more quality- and performance-based funding system. However, realising such minimum-scale conditions will only be feasible if the Bulgarian authorities are prepared to bring about a major structural transformation and concentration of research activities.

Therefore, the structural reform of the Bulgarian HE and research landscape is essential for the introduction of any performance-based funding scheme. Consolidating the research landscape will also enable the major imbalances and poor interactions within the national research and education system to be addressed in a more direct way. These include the weak research-teaching link within HEIs; the low quality of HEIs and significant brain drain of young talents; the mismatch between the profile of HE graduates and the actual demand in the labour market; and the poor research-industry collaboration, knowledge exchange and technology transfer between the public and private sectors.

Once the potential for closer interactions between the research system's different nodes have been optimised, the more integrated HE and research system will profit from being more effective in being able to reward high performance, thanks to its higher concentration of resources.

In designing measures for such a new PRFS, it will of course be vital to obtain both a consensus with the 'new' set of stakeholders, recognising the intrinsic limits with respect to performance indicators, and finding a balance between, on the one hand, stable and predictable funding conditions in which those new stakeholders can develop their own, autonomous long-term strategies and, on the other hand, fully exploiting the incentives of performance-based funding to find their own 'stairway to excellence'.

3.2 Structural reform of the Bulgarian research system

In this section we first give an overview of the key concepts and 'lessons learnt' from international experience related to the consolidation of research systems before setting out our views on the potential characteristics of the structural reform in Bulgaria.

3.2.1 Reform of research systems in the international landscape

Since 2000, mergers or concentration processes have occurred or been discussed in a large majority of Europe's national research systems. The most recent and comprehensive study on this phenomenon is the 2015 study 'Designing Strategies for Efficient Funding of Higher Education in Europe (DEFINE)', conducted by the European University Association and co-funded by the European Commission (Pruvot, Estermann, & Mason, 2015).

The DEFINE study identified a **wide array of drivers** for these mergers and concentration processes:

- Increasing the quality in both research and teaching activities, thanks to the pooling of academic talent and infrastructure, more financial or staffing resources, and opportunities for interdisciplinary research with a wider variety of academic subject areas.
- Overcoming fragmentation, achieving critical mass, especially in research, avoiding duplication of programmes or eliminating poor-quality programmes, creating synergies (for instance by integrating universities and research institutes) and reacting to the demographic decline.
- Strengthening the institutional position on the international stage facilitating an increase in staff and students from overseas as well as providing more opportunities to undertake international collaboration.
- The realisation of economic gains, such as economising financial and human resources, and the creation of economies of scale to generate more revenues or for the provision of services and possibilities for streamlining arising from the enlarged infrastructural stock.

The DEFINE study also distinguishes between **different types of mergers and concentration processes**. Apart from the size of the institutions involved and their characteristics in terms of institutional profiles and/or status, a major feature concerns the depth of the integration process. Institutions may decide to opt for comprehensive integration rather than a full merger, whereby they retain their individual legal status but fall under a wider umbrella organisation in a federation model. This could be the purpose of strategic management or more practical matters such as sharing resources and, according to the DEFINE study, is normally undertaken by institutions within a certain region or geographical proximity. At the other end of the spectrum, there are full mergers whereby the institutions concerned consolidate their resources and become a single legal entity.

Based on experience in the European landscape, the DEFINE study recommends that the choice of concentration should be based on careful consideration of the costs of the opportunity for a merger and the various cooperation options available. The authors emphasise, "A strong academic rationale for merging must be backed up by a solid economic case. Both elements are essential pillars of a successful merger."

In several countries, public authorities have promoted mergers and concentration processes – either among or between HEIs and research institutes – as a tool to accomplish a system-level reform. **Consolidation of the system** was a driver for the mergers and concentration processes in, for example, Belgium/Flanders, Denmark, Finland, France, Hungary and Latvia.

Denmark is a prime example – an important system-level process was completed there in 2007 involving two types of mergers to further strengthen the university sector's global competitiveness: mergers of government research institutions into universities and mergers among universities themselves (from 12 full universities in 2003, the system was reduced to 8 universities). The Danish reform illustrates a trend that is visible in most European countries towards the creation of closer links between research institutes and universities.

The reform of the research system in Denmark (1)

By 2007, Denmark had put into practice an important system-level process, whereby several HEIs merged among themselves and with government research institutes. All Danish universities except three were affected by the mergers. The number of 12 full universities in 2003 was reduced to 8 universities in 2007. During the process, nine governmental research institutes were merged with universities (two as early as 2004) and the former independent government research institute sector almost disappeared.

The rationale for the mergers included *economies of scale*, pooling resources, technical facilities, buildings etc. and the possibility of saving administrative and possibly teaching costs. Larger and more comprehensive institutions were expected to lead to stronger academic programmes, improved student services and opportunities for student choice, greater institutional flexibility, and more *competitive* research groups. Competitiveness was seen in the context of the ongoing *globalisation* and the formation of a global European market for HE. (Aagard, Foss Hansen, & Gulddahl Rasmussen, 2016)

The **government has an important but delicate role to play** in this process. Again, the Danish reform process can provide inspiration here (see below). In any case, policy support for the merger and concentration processes is of fundamental importance, including the availability of additional financial resources for the institutions involved to prepare and organise the process.

The DEFINE study also emphasises that communication and effective information management are key. The benefits of consolidations or mergers need to be articulated to all affected parties, especially the university faculty and rectors concerned. Transparency is essential to secure buy-in from all those concerned, which in turn is essential for the successful conclusion of the initiative. In other words, a university merger is not a company takeover.

The reform of the research system in Denmark (2)

The need for mergers was put on the agenda as early as 2001, and over several years reviews and working groups proposed various ways to achieve the merger process, which met with scepticism and criticism both among the potentially merged institutions and the various ministries. The mergers were originally intended to be an open process, but because this did not lead to concrete results, government action was eventually taken in 2005 and led to the mergers of 2007.[7] The merger process was enabled by the new University Act of 2003 which introduced to universities a new, hierarchical management model and boards with a majority of external members.

The merger process was comprehensive and involved multiple phases. In February 2006, the universities and government research institutes were asked to submit expressions of interest in merging with potential partners either from other universities or the government research institutes. After negotiating with the institutions and a yet another round of submissions, the ministry announced the plan in October 2006. The last of the mergers took place in February 2007.

The process was conducted through inter-institutional dialogue and negotiations; it had both voluntary and coercive elements since the government put pressure on the institutions to oblige and took the final decisions. The government attempted to find a delicate balance

[7] Before that there had been mergers within the professional HE and university college level, which, however, are not dealt with in this context.

between exerting pressure, where it saw it as important, and accepting deviations from the original overall objectives, rather than imposing a full solution. By pursuing this strategy, the overall result turned out to be acceptable for both the government and the institutions (Melin, 2015).

The follow-up process

Factors both before and after the merger affect the degree to which it can achieve its objectives. Studies conducted in Denmark indicate that even eight years after the mergers, the process was still ongoing (Aagard, Foss Hansen, & Gulddahl Rasmussen, 2016). Multi-partner and cross-sector mergers pose special challenges being more complex and having to work with different research cultures, missions and funding patterns before the merger. The degree to which the merger is voluntary, and the type of governance structure adopted after the merger affect the merger processes. Aiming to achieve a unitary, fully integrated governance structure afterwards usually meets with more scepticism than a federal structure in which the merged institutions maintain their special structures and responsibilities.

3.2.2 Consolidation of the Bulgarian research system

In Bulgaria, we see the need for two lines of action: concentration of the **HE sector** and a **system-wide reform** to reap the full benefits of the academies' research capacity by creating synergies in the system – based on the **missions** of the research institutes and universities.

In most countries, the research system comprises a mix of research institutes and HEIs. These research-performing organisations have different functions in the R&I system and, in particular, different missions in society; performance assessments and PRFS are typically geared towards taking these different functions and missions into account.

- **Non-university research organisations** can be categorised into three main typologies reflecting their function in the R&I system and their mission in society, i.e. scientific research institutes, research and technology organisations (RTOs), and government laboratories (see Table 7, below). (Arnold, Barker, & Slipersaeter, 2010). This categorisation is not all-encompassing. Often, larger 'national' RTOs, which play an important 'infrastructural' role in their respective country, have several distinct missions. These RTOs typically combine, for example, advice to government, public laboratory services (e.g. assaying, norms and standards), condition surveillance (e.g. environmental monitoring), hosting facilities as well as strategic research and contract R&D for enterprises. (EARTO, 2013).

  The BAS institutes combine a mixture of scientific research institutes, RTOs or RTO/scientific research institute hybrids, and government labs. The AA includes primarily government labs that also do some degree of extension work in the agriculture sector, although there are also institutes that would be better classified as scientific research institutes.

  The OECD also identified another category of non-university research organisations, i.e. ROs that have research only as a secondary function (OECD, 2011). These include entities with strong public-service goals (e.g. hospitals) or a strong cultural focus (e.g. museums and libraries). In some countries, these institutes are considered as an integral part of the research system or research infrastructure (e.g. in the Czech Republic, Italy and

Denmark). An example of such PROs in Bulgaria are the research institutes that were integrated into the hospitals following the closure of the Medical Academy in 1992.

- **HEIs** typically are an integral part of the scientific research component of the R&D system, including the university hospitals. They perform a wide range of roles, responsibilities and activities, and cut across different economic, political and social networks. (Jordi Molas-Gallert et al., 2002) However, their primary mission is education and within this context, they have an additional role to play in the national innovation system, i.e. the education of the future researchers - to the benefit of research and the industry sector alike.

Table 7: Typologies of PROs and their function in the R&I system

Type of PRO	Examples	Function in the R&I system
Scientific research institutes	The Max Planck institutes in Germany, CNRS in France, etc.	To conduct basic and applied research, in the pursuit of knowledge
Research and Technology Organisations (RTOs)	VTT Finland, the Fraunhofer Society in Germany or TNO Netherlands	To create, discover, use and diffuse knowledge, promoting industrial competitiveness through technological means and tackling industry's needs for knowledge by providing skilled graduates to industry and a range of knowledge-related services, by de-risking industrial innovation and by contributing to the available knowledge stock
Government laboratories	Nuclear research institutes, marine institutes, metrology institutes etc.	To produce public goods to meet knowledge needs of the state or wider society by providing fundamental research in strategically important areas, supporting public policy through precautionary research policy design and monitoring, supporting the building of technical norms or standards, and/or constructing, maintaining and operating key facilities

Source: (Arnold, Barker, & Slipersaeter, 2010).

At the level of **HE**, we advise the Bulgarian authorities to strive for a university landscape – i.e. HEIs involved in ***both*** teaching and research – consisting of no more than eight of the current 37 publicly funded universities. That would mean a one to one-and-a-half publicly funded research university per million population. This is a broad, general rule of thumb which appears internationally tenable.

At the same time, the consolidation of the Bulgarian HEIs around a maximum of eight universities would force those 'new universities' to recognise their ***research mission*** much more explicitly within their regular teaching activities, thereby strengthening the poor teaching-research and research-industry link within the Bulgarian HE system. Ideally one could imagine a Bulgarian HE landscape consisting of:

- Research universities competing at European and global level with the rest of the world both in high-quality, excellent research and postgraduate education

- Entrepreneurial universities focusing more on the valorisation of research, the creation of new enterprises and university spin-offs, and more broadly the teaching across all disciplines of entrepreneurial skills
- Other HE establishments that would have a purely professional education role, limited to the undergraduate level and linked, for example, to regions' 'smart' specialization.

In order to exploit the research excellence of the BAS and AA institutes more fully, we propose a **two-fold structural transformation of the Bulgarian research institute sector**.

First, we would suggest opening up the possibility for the BAS and the AA to each create an **'academy research university'**[8], building on the current strengths of BAS' and AA's strongest scientific institutes, and focusing on both research and postgraduate education (Master's and PhD). With the eight 'research universities' following the HEIs reform discussed above, this would imply that Bulgaria's HE landscape would ultimately comprise 10 universities: eight having emerged from the current fragmented HEI landscape and two new ones building on the research excellence expertise of the BAS and AA.

Secondly, and with respect to the more technologically oriented RTO-type of research institutes, we would suggest **close collaboration, where possible even integration** within the new category of 'entrepreneurial universities'. There is a clear need for strong links between the RTO-type research institutes with universities even though RTOs do very different things compared to universities. RTOs need industrial experience, industrial project management, commercial-style management systems, etc. as the German Fraunhofer model illustrates well. In other countries such as the US, 'industrial extension services' (e.g. Georgia Tech) RTOs have been 'bolted' on to the side of universities. We propose to follow this line by bolting those Bulgarian RTOs to the new set of 'entrepreneurial universities'[9] described above. In doing so, they will immediately have access to an applied technological research base from which the research-industry relationship might be further strengthened.

The remaining BAS and AA institutes should **integrate within the HEIs**, in particular in the eight 'research universities'.

Exactly how this structural reform could be done is open for discussion and by and large outside of the scope and mandate of this H2020 Specific Support study group. However, a relatively straightforward way to initiate such a radical restructuring process might consist of using a public tender to open up the creation of the new research/entrepreneurial universities to HEIs and BAS and AA institutes alongside the lines discussed here, with an international independent jury evaluating the various proposals submitted.

[8] The Max Planck university in Germany comes to mind in the case of the BAS or Wageningen University in The Netherlands in the case of the AA.
[9] The Fraunhofer Gesellschaft universities come to mind.

3.3 A significant increase in the public funding for research

In 2012, a policy note by the World Bank stated: "Bulgaria's competitiveness challenge is to 'grow smart', which means making research and innovation one of the major drivers of economic growth." (World Bank, 2012). The report emphasised that there was an urgent need to **reverse the erosion of Bulgaria's technological and scientific competences** through more strategic support of R&I and considered that raising the R&D-intensity of the economy was one of the main challenges ahead.

Numerous reports[10] – both international and national, prior to and after the 2012 World Bank report – have called for a change in government policy related to funding research and insisted on the need for an increase in the national public funding of research. We have not seen one paper where the underfunding of research did not figure 'on the front page'. The 2015 H2020 PSF Peer Review made the following observation:

> *"The current low level in public funding of research and innovation in Bulgaria is in the view of the PSF panel* ***not sustainable****. If not reversed, it might lead to a further downward adjustment in the structure of the Bulgarian economy, the lack of public investment negatively shaping the training and skill acquisition of the human capital needed to perform R&D activities, so that the country becomes actually less attractive to foreign R&D investments, and at the same time negatively affecting the existing pool of knowledge available within the system so that companies benefit less from spill-over effects and positive externalities. Effectively it could mean a process of "submerging" as opposed to emerging development; Bulgaria not being capable of maintaining its historically high level of human capital and gradually adjusting its economic structure downwards once the older population with its relatively high human capital retires and cannot be replaced due to a lack of young human capital."*

Unfortunately, current data show that the public underfunding of research has not yet reversed but instead continues its downward trend (see Section 2.2.1, above).

The reform we propose above goes beyond the concept of accountability and implies a thorough transformation of the research system. It can be successful only if the trust relationship between the higher education/research community and the government is restored.

To achieve maximum stakeholder support for the reforms proposed here, we would therefore suggest that the Bulgarian government quickly commits to **increase its annual public funding of research by some EUR 100 million over a few years, effectively doubling public research funding**.

Such an increase in public funding should be conditional on implementing the structural reforms proposed here. To put it in a more direct way, if such additional funding is not accompanied by structural reform, it would effectively mean a mere

[10] To name but a few: the EC ERAWatch reports of 2009 and 2010; the EC RIO reports of 2014, 2015 and 2016; the World Bank reports of 2012 and 2017; the OECD LEED report of 2014; and the 2017 National Strategy.

EUR 750k additional funding for each of the 130+ research institutions in Bulgaria resulting in a very limited impact. By contrast, if the EUR 100 million in additional funding is earmarked for the new proposed research landscape comprising between 10 to 12 players, it would represent significant additional annual investment for each of those institutions.

3.4 Summary and recommendations

We believe that a **structural reform of the Bulgarian research landscape is an essential precondition for any PRFS to be effective.** The gravity of the current challenges in the Bulgarian R&I system and the extent to which fragmentation is embedded in the cultural and political context lead us to consider that a 'passive' or 'indirect' restructuring of the Bulgarian research system is not a viable option. In addition, while a PRFS could make a contribution to restructuring such a system, it is unlikely that alone it could correct the various inefficiencies, overlaps and systemic failures in Bulgaria's research system quickly and profoundly enough to reverse the current decline in the Bulgarian research system. Unless the PRFS is combined with structural reform, it cannot be expected to help overcome research fragmentation. Consolidating the research landscape will also make it possible to address the major imbalances and poor interactions within the national research and education system in a more direct fashion.

In our view, the Bulgarian research system has first to be reformed in terms of **reaping minimum-scale advantages**. Scale is less important in some scientific areas than in others, but some minima are essential for a research field not only to survive and sustain itself (PhD fellows, renewal of staff) but also to grow and advance up the 'stairway to excellence', or to increase its societal impact. Consolidating the research landscape will also make it possible to address the major imbalances and poor interactions within the national research and education system more directly. Once the potential for closer interactions between the different parts of the research system has started to be realised, there will, in the view of this expert panel, be much more room for a performance-based research funding scheme, as proposed in the PSF Peer Review.

We suggest a new research landscape consisting ultimately of a maximum of some 10 to 12 research players:

- **some five to six 'new research universities'** consisting of a number of existing Bulgarian HEIs which commit themselves to research in their primary HE mission and one or two BAS and AA 'academic universities' based on the bundling of existing research excellence within a number of academic institutes which are now prepared to commit to postgraduate education alongside academic research in their mission; and
- **a broadly similar number of five to six 'new entrepreneurial universities'** based on a close collaboration, leading ultimately to the gradual integration of existing technical HEIs and RTOs in areas of smart specialization, with a focus on applied technological research and a strengthening of the research-industry relationships.

In the view of this expert panel, once the reforms proposed have been implemented or agreed upon, there will be much more room for a performance-based research funding scheme, as proposed in the PSF Peer Review. In this new research landscape, a PRFS will be an important and welcome instrument to further incentivise and evaluate those new research players on their *stairway to excellence* and *greater societal impact*.

Bulgarian authorities are invited to increase substantially – a doubling appears a reasonable target – the public funding of research, whereby such additional funding would be earmarked to those new players only.

4 THE DESIGN OF THE CURRENT PRFS

In this chapter, we set out the concepts of the Bulgarian PRFS (as described in the 2017 National Strategy) and the characteristics of the current national evaluation methodology (defined in the 2015 Regulation) within the context of international practice. This allows us to formulate recommendations for an improved design of the future PRFS.

The analysis in this chapter is based on the following understanding of how PRFS work in the international landscape:

- PRFS are instruments used to **implement policy** and are adopted in order to pursue policy objectives in the national context. The linking of funding to the evaluation results against specific indicators is intended to **create incentives** for a certain practice of research, producing behavioural or structural changes in the R&I system
- There is a need for the criteria used in the PRFS assessment to be **consistent** with the objectives of policy. The weights in the funding formula are a key aspect of the link to policy because it involves deciding the **relative importance** of the various policy objectives
- Very often, PRFS are complex systems. However, an appropriate **trade-off between perfection and practicality**, avoiding unnecessary complexities, is critical for the design of a transparent – and therefore effective – PRFS
- In order to create their intended effects and to be accepted and endorsed by both policymakers and research performers, PRFS should, first and foremost be **fair, transparent, simple** and should involve **low costs**
- Along with the presence of nuanced and sensitive indicators and formulae, **adequate management systems and databases** for the metrics are essential for the trust in and transparency of performance-based funding
- PRFS are prone to gaming and present the risk of creating perverse effects. A rule of thumb is that the use of several indicators based on the same assumptions should be avoided as it risks multiplying the impact of potential errors or injustice to specific fields

Multiple factors play a role in the design of a PRFS and it is beyond the capacity of this study to be exhaustive on the matter. This chapter focuses on those aspects that are of critical relevance in a PRFS and/or that, in our opinion, are particularly problematic in the current design of the evaluation methodology.

We start by setting the PRFS in its **policy context**, considering the policy purposes and how these are reflected in the choice of indicators. The next section focuses on the **evaluation component** of the PRFS. We assess the quality of the indicators, their use and design, and discuss the quality of the data sources. We then cover its **funding component**. We discuss the need for the definition of thresholds and volume measures as well as the use of weights in the funding formulae, and reflect on the role of the PRFS in the research funding mix. We conclude with some considerations on the use of the evaluation methodology for the **individual researcher's** 'regular attestation'. A summary of the main findings and our recommendations are provided at the end of each of these sections.

4.1 Policy purposes and the choice of indicators

In a PRFS, the criteria and indicators used in the evaluation are selected to reflect the goals that policies aim to promote. The expectation is that rewarding specific behaviour patterns or outputs will change the behaviour of the individuals, groups, and institutions being evaluated. The assessment criteria and indicators should therefore reflect the policy purposes of the PRFS, which may change over time**.**

In the sections below we first set out the patterns and approaches in the international landscape to then consider the policy purposes of the current PRFS in Bulgaria and their reflection in the indicators used. We also analyse the incentives that the direct link between indicators and funding formula create and consider the potential risks that they present for the creation of undesired effects. A summary of our considerations and related recommendations is set out in Section 4.1.4.

4.1.1 Policy purposes and indicators in the international landscape

Internationally, the purposes of PRFS vary, depending on the pre-existing state of research in the countries, the national research priorities, and more generally – the approach to research governance. Earlier studies observed four main **categories of policy purposes** (OECD, 2010) (Mahieu & Arnold, 2015):

- to enhance the quality of research and the country's research competitiveness
- to steer behaviour to tackle specific failures in the research system
- to strengthen accountability
- to provide strategic information for research strategy at institutional and/or national level.

Most countries use PRFS in an effort to enhance the **quality of research**. Most also aim to trigger **other behaviour**, in line with policy priorities or a perceived need for change in the national research system. Since the 1990s, governments have become increasingly explicit that universities should pursue a 'third mission' of sharing knowledge with the wider society and supporting innovation in addition to teaching and research. Specific objectives include: fostering critical mass; enhancing research-industry collaboration and knowledge transfer; identifying or directing funding toward areas of research strength and emerging areas of research excellence; and strengthening the international competitiveness of research (NZ Ministry of Education, 2012). Some countries also seek more **accountability-related objectives**, to stimulate efficiency in research activity and to demonstrate that investment in research is effective and delivers public benefits (Abramo, D'Angelo, & di Costa, 2011).

Table 8, below, gives more detail about PRFS policy objectives and the aims of countries that participated in the H2020 PSF Mutual Learning Exercise on PRFS. It confirms the importance of quality as the main policy purpose. Norway and Turkey are trying to increase productivity in their countries, while transparency and accountability are important in Austria, Croatia, Czech Republic and Italy, presumably with the intention of demonstrating to decision-makers and taxpayers alike that national investment in research is worthwhile. Armenia, Estonia, and Slovenia are using PRFS to promote systemic changes.

Table 8: Main policy purposes of PRFS in countries participating in the PSF MLE on PRFS

	AM	AT	HR	CZ	EE	IT	MD	NO	PT	SI	SP	SE	TR
Quality	X			X		X	X	X	X		X	X	
Productivity								X					X
Overall competitiveness	X	X					X						X
Transparency & Accountability		X	X	X		X							
Systemic changes	X				X					X			

Source: Debackere, Arnold, Sivertsen, Spaapen & Sturn, 2017

Indicators used in research evaluations can be grouped into five categories, i.e. output, process, external funding, systemic, and outcome/impact indicators. The relative importance placed on these indicators (in terms of the number and/or the weight attributed for calculating the score) depends on the purpose of the evaluation. (Mahieu & Arnold, 2015)

<u>Output indicators</u> usually relate to the quality of research outputs, but several PRFS also assess the productivity, quality and value of non-academic outputs, such as studies providing strategic information for public policy and innovation-related outputs such as patents or other forms of IPR. Bibliometric indicators related to **research productivity** are particularly stressed in those R&D systems where lack of productivity is a cause for concern (e.g. Norway, Italy and the Czech Republic). Assessing **research quality** is at the core of all PRFS, aimed at fostering the quality of the research conducted, alongside the quantity.

Most of the countries also consider the number of PhDs awarded as an output of research activities as a contribution to the (future) strength and capacity of the national research system.

<u>Process indicators</u> help to ensure that high-quality outputs are not created in an insular fashion with little **knowledge transfer** benefits to the wider research community. These indicators (e.g. participation in international conferences) implicitly recognise that the process of research itself can, to varying degrees, be shared with other researchers; the resulting dialogue and transparency may then allow for new perspectives to be developed, regardless of the publication or prestige of the output channel.

<u>External funding indicators</u> address the **quality** of research (competitive strength) and sometimes its **relevance** to wider contexts. External funding in

the form of national or international competitive funding, corporate funding, contract research, etc. also indicates the degree of research alignment with wider national or international scientific, social or economic concerns and priorities.

Many PRFS use the amount of research funding from particular external sources as quality indicators, so they can be used to magnify the effects of external funding – typically in the direction of 'excellence' or 'relevance' or internationalisation via participation in the EU Framework Programme for research and technological development. External funding indicators are also used to trigger systemic changes. For example, Croatia, Estonia, the UK, Italy, Finland and Norway all reward external research income from industry and other societal stakeholders, with the aim of improving industry-research links.

Systemic indicators are a response to the fact that research outputs are in themselves poor measures of the overall health and quality of a research system, especially in terms of collaboration and mobility, leading to the **exchange of knowledge and expertise** – with other components of the national innovation system (industry, education, research, etc.) or at an international level. These are focus points especially for PRFS where a major intent is to steer research behaviour to overcome specific systemic failures (e.g. in Norway to encourage institute-HEI collaboration, in Finland to enhance internationalisation, and in Italy to increase science-industry collaboration).

The use of indicators directly assessing outcomes or impacts is rare in international practice. Typically, effects of research activities in the economic or societal sphere are captured through narratives. In a few countries, effects related to innovation are measured by counting the number of spin-offs created. In other countries, the number of citations and/or publications in journals with high-impact factors are considered **proxies** for outcomes in terms of impact on the research base.

Table 9 shows the categories of policy objectives to which the different types of indicators are most relevant. It highlights that different types of indicators address similar objectives from different perspectives. This is of particular importance when deciding on the **'indicator mix'** in the PRFS, considering that the way particular indicators are calculated can impact their effects.

Table 9: Overview of indicator types and use

	Research productivity	Research quality	Relevance of research	Systemic changes (collaboration, knowledge exchange etc.)
Output indicators	X	X	X	X
Process indicators	X		X	X
External funding indicators		X	X	X
Systemic indicators			X	X
Impact indicators		X	X	

4.1.2 Policy purposes and indicators in the Bulgarian PRFS

Based on the description in the 2015 Regulations and the 2017 National Strategy, the **main purpose** of the current PRFS is to increase both the **accountability** of the research institutions and the efficiency of the research funding by concentrating the latter on those institutions conducting **quality research**. The specific objectives are:

- To enhance research capacity and stimulate scientific research in universities;
- To improve quality in research (both at the level of individual scientists and organisations), increase the quality of research results, and reward excellence in research;
- To promote international collaboration in research;
- To create the conditions for increasing research funding by enhancing the accountability of HE and research organisations and by overcoming the fragmentation of research funding.

Thus, the Bulgarian PRFS shares many commonalities with other PRFS, specifically in its focus on enhancing research quality and competitiveness, combined with strengthening accountability. It distinguishes itself, however, by its explicit and **close-to-exclusive focus on scientific research** and potential effects of the research activities **in the scientific sphere**.

Set within the framework of the of the policies and specific objectives defined in the 2017 National Strategy (Table 10), the assessment criteria and indicators in the current evaluation methodology mainly address the "policy for the development of fundamental research and stimulating excellence science" and the expansion of international cooperation within the international scientific community (SO9). The only exceptions are the patent-related indicators and contract research funding. The relevance of research for society beyond the private sector is not considered in any type of indicator.

The choice of the research output indicators also indicates a strong emphasis on rewarding quality of research in terms of 'impact' (i.e. citations), which is considered an expression of **'excellence',** rather than incentivising research capacity by rewarding productivity or collaboration in research. Of the four policy objectives listed above, there is no doubt the evaluation methodology addresses least of all the first one related to research capacity.

Most important, while the current evaluation methodology creates incentives that address most of the capability failures in the Bulgarian R&I system, it does not consider any of the **institutional failures** such as the fragmentation of the research system. There is no use of indicators to incentivise collaboration and knowledge exchange among research actors in the national system (e.g. co-publications or the joint conduct of research projects). To summarise, the current PRFS design seems to be based on the assumption that fragmentation of the research system will be tackled by focusing the funding on excellent research. These findings enforce our consideration in the preceding chapter that the necessary restructuring of the Bulgarian research system by means of the current PRFS only is not a viable option.

Table 10: Assessment criteria and indicators set within the policy framework

Policy	Assessment criteria	Assessment indicators
Policy for the development of human potential (SO3)	Research capacity	• No of PhD awards • No of research staff members in three career phases (3 indicators)
Policy for the development of fundamental research and stimulating excellence science (SO 5)	Research outputs	• No of scientific publications • No of publications in impact journals • No of publications in top 10% impact factor journals • Averaged h-index • Number of monographs
	Science capacity	• External research funding from public sources (2 indicators)
Integration policy in the European Research Area and expansion of the international scientific cooperation (SO 9)	National and international distinction	• Membership of journal boards • Memberships of international scientific, networks/companies (2 indicators)
Integration policy in the European Research Area and expansion of the international scientific cooperation (SO 10)	Research outputs	• Number of patents (3 indicators)
	Science capacity	• External research funding from industry

4.1.3 Incentives created by the indicators and criteria

The analysis of the incentives that specific indicators directly create for individual researchers and their research institutions allows for a quality check of the indicators used as well as for an assessment of the extent to which the PRFS risks creating unintended negative effects (Our suggestion is to improve these indicators by including contract research funding from public administration and eventually other societal partners as a proxy (and incentive) for societal-relevant research. This should be separate from the indicator on contract research from industry which assesses (and creates an incentive for) science-industry interaction, which constitutes one of the most significant failures in the current Bulgarian research system.

As mentioned above, external funding indicators are increasingly used as quality indicators. They present the potential to create an incentive (and reward) for the conduct of international research by distinguishing between national and international public funding (rather than the current distinction between types of projects). It should be noted, though, that this would entail rewarding those institutions that are among the most competitive. It risks leading to a further concentration of resources, potentially at the expense of wider capacity-building in the research system, and reinforcing existing resource hierarchies.

Table 11). It further illustrates our conclusions of the analysis in the preceding section. The major issues are:

- **The pronounced focus on 'excellence' indicators**

The current evaluation methodology includes several indicators that constitute an incentive for institutions to hire – and/or to maintain in employment – 'excellent' senior researchers. The strong emphasis on excellence, especially in the 'research outputs' criterion, risks creating important negative effects on the career prospects of PhD students and postdocs, which should be avoided in a research system that is confronted with a considerable level of brain drain.

- **The exclusive focus on patents as an IPR indicator**

The assessment of IPR activities exclusively in terms of patents is problematic from a field/sector-specific perspective. It creates incentives for innovation-related activities to the benefit of some specific industry sectors only, neglecting sectors that are of high importance in the Bulgarian economy (see Section 2.2.6).

Patenting is important for a few science-based sectors, such as pharmaceuticals, chemicals and parts of electronics, i.e. the sectors that are highly dependent on scientific advances and rely on patents as a source of competitive advantage. Patenting and patent commercialisation activities can therefore be expected to be higher in some fields (e.g. pharmacy) than in others (e.g. industrial engineering). In view of the market structure of Bulgaria, one would expect the IP indicator to include at least <u>copyrights, trademarks, registered design and plant/breeders' rights</u> in order to fully reflect the IP outputs of research in Bulgaria.

Another desirable improvement in the patent indicator is to make a clear distinction between the stages of application, delivery and licensing.

- **Three indicators related to the research staff profile in the 'science capacity' criterion**

These indicators are not suitable for use in a metrics-based performance assessment. They do not create useful incentives for the creation of a critical mass. In combination with the volume measure, they risk creating negative effects on the hiring of research staff, such as technical staff, who have an important role in supporting the conduct of research in some specific fields. Our advice is to drop these indicators.

- **External funding indicators**

The external funding indicators seem to be included in the evaluation to measure capacity and influence the decision-making on eligibility for funding rather than for the purpose of performance assessment (see Section 4.3.1, above). Our suggestion is to improve these indicators by including contract research funding from public administration and eventually other societal partners as a proxy (and incentive) for societal-relevant research. This should be separate from the indicator on contract research from industry which assesses (and creates an incentive for) science-industry interaction, which constitutes one of the most significant failures in the current Bulgarian research system.

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Table 11: Incentives created in the current PRFS

Indicators	Researcher incentive	Institutional incentive
1. RESEARCH OUTPUTS *(U1)*		
No of science publications in global secondary literary sources (A)	*Increase no of publications, irrespective of the publication channel*	*Employ and promote productive staff*
No of science publications in journals with impact factor (Web of Science or SCOPUS) (B)	*Increase no of publications in internationally indexed journals with impact factors*	*Employ 'excellent' researchers*
No of science publications in the top 10% of impact factor journals (B1)	*Increase no. of publications in internationally indexed journals with particularly high impact factors*	*Employ 'excellent' researchers*
Number of monographs (D)	*Increase production of monographs (and books?)*	*Employ people who write monographs*
No of citations/references in science literature (G)	*Aim for high citation rates irrespective of the publication channel*	*Employ 'excellent' researchers*
Averaged *h*-index according to SCOPUS data	*Publish in journals indexed by SCOPUS*	*Employ people who publish in journals indexed by SCOPUS, especially older people with high h-indices*

Indicators	Researcher incentive	Institutional incentive
Number of patents: registered patent applications; patents; patents resulting from contracts with industry	*Apply for patents whenever possible, irrespective of whether they are likely to produce an economic return;* *Carry out research for innovation likely to be patented*	*Encourage, employ and promote people likely to do research with/for industry in patentable technologies*
2. SCIENCE CAPACITY *(U_2)*		
Number of fellows who hold the educational-science degree of "Doctor" (N_d)		*Employ people with Doctor, Science Doctor and Professor degrees* *Minimise the number of other staff*
Number of fellows who hold the science degree of "Science Doctor" (N_s)		
Number of fellows who hold the academic position of „Professor" (N_p)		
Funds from the project-based funding system in Bulgaria and abroad (*K* BGN)	*Apply for this type of research funding, nationally or internationally*	*Encourage staff to apply for this type of research funding* *Employ less-costly (junior) staff*
Funds from project funding *(P)*		
Funds from contracts with Bulgarian or overseas enterprises (V)		
No of doctoral students, who defended their thesis during the reporting year (*R*)		*Maximise PhD student recruitment and minimise completion times*
3. NATIONAL AND INTERNATIONAL DISTINCTION*(U_3)*		
No of memberships in editorial boards of science journals *(S)*	*Solicit invitations to journal scientific boards*	*Encourage people to invite colleagues*
No of memberships in international science networks	*Join international science networks*	*Join international science networks*
No of memberships in international science societies	*Join international science societies*	*Join international science societies*

4.1.4 Summary and recommendations

The PRFS and its evaluation methodology must be understood against the background of the long-running tension between public research and teaching institutions and the government and underfunding of research. It aims to establish a better balance between the autonomy of public research and teaching institutions and their accountability.

The choice of indicators reflects this purpose. However, it appears to be based predominantly on priorities internal to the research system (quality/excellence of research) with little regard for the importance of knowledge exchange with actors external to the research community and for the relevance of research, be it for industry or society at large. This generates a very narrow conception of 'accountability', linked solely to the traditional, internally-centred conception of a research institution and paying no attention to its interaction with the other parts of the knowledge triangle. This is unlikely to persuade either the taxpayer or the government that scientific research should be funded not only in its own right but also because it generates pay-off for society. **We recommend that the Bulgarian authorities take a broader view of the concept of 'quality' in research and consider the relevance of research for industry and society as inherent to the concept of research 'quality', also in the case of 'targeted' fundamental research.**

The current PRFS design seems to be based on the assumption that fragmentation of the research system will be tackled by focusing the funding on excellent research. The evaluation methodology does not appear to address the systemic effects, both positive and negative, that research funding linked to performance may have, nor does it attempt to incentivise behavioural changes over and above raising quality and international presence. Thus, crucial aspects of research system performance, such as the relevance of research to societal needs and its impact upon these needs and the collaboration in research, are not addressed. **We recommend the Bulgarian authorities to make greater use of evaluation as a *policy tool*. Incentives should be created for behavioural changes related to major structural failures in the research system for the PRFS to fulfil its function in supporting the recovery of the Bulgarian research system.**

The strong focus on research excellence, understood mainly as international competitiveness, risks exacerbating rather than addressing important current failures in the system, such as the brain drain, insufficient research capacity and productivity and the lack of research-teaching and research-industry links. The strong focus on internationally relevant research outputs risks creating a 'horizontal fragmentation' in the national R&I system, i.e. concentrating funding on 'islands of excellence' in research that are not necessarily relevant in the local context (Radosevic & Lepori, 2009). **We recommend the Bulgarian authorities look for a better balance between fostering the creation of capacity for research and rewarding 'excellence' in research, as well as between rewarding internationally versus nationally relevant research.**

4.2 Quality of the indicators and the data sources

In this section, we cover in-depth the quality of the indicators in terms of choice, use and design from a more technical perspective. We focus in particular on the bibliometric indicators because they constitute the core of the current evaluation methodology. They are used also to assess research activities in the context of HEI performance assessment, and can be expected to constitute the criteria against which individual researchers will be assessed, within their institutions and for the envisaged 'attestation'. In several cases, our reflections and suggestions directly respond to problems that emerged from the 2016 and the 2017 pilot evaluations and the evaluation reports.

We start this section with a focus on two key elements that determine the quality of a research evaluation system: the fairness of the evaluation, thanks to the appropriate attention to the differences in research practice in the different fields of science through 'field normalisation', and the definition of the reference (or 'reporting') period for data collection. We then cover in detail the two types of indicators used to assess research quality, i.e. the scientific output indicators and the scientific impact ones. Finally, we cover a major challenge in any evaluation, i.e. the quality of the data sources. Section 4.2.6 presents our main findings and recommendations.

4.2.1 The fairness of the evaluation

The fairness of a research evaluation system depends on the extent to which it takes account of the specifics in the scientific fields. Differences among **disciplinary cultures** derive from the history of the disciplines or research fields and are influenced by their size and the way in which research is conducted. They are expressed in terms of output types, main publication patterns, channels and timelines, citation behaviour, language of publication, collaboration behaviour and needs, intensity of the use of and need for (human and financial) resources and research infrastructure, and so on. Differences in communication practices among scientific disciplines range from the preferred form, outlet and publication channels to publication propensity and citation practices.

There are major differences among the fields in their propensity to publish (Mahieu & Arnold, 2015). Mathematicians write few but extensive articles; chemists produce many short articles. A good biomedical researcher will be able to publish around five articles from a given research project, whilst in engineering this ratio is significantly lower, for example. There are also differences according to the type of research. In high-energy physics, for example, theorists tend to publish more frequently than experimentalists (Butler L. , 2007).

Citation frequencies and productivity vary significantly among fields, partly because publication and referencing practices differ and partly because the fields may be covered to a different degree in the database used for the measurement. For example, medical researchers tend to produce more, often shorter papers where methodology and prior knowledge is codified in citations; engineering scientists produce articles less frequently with fewer citations (Sandström & Sandström, 2009).

The most obvious and most frequently cited examples in the literature in terms of publication types and channels are the differences that exist between the natural and physical sciences on the one hand, and the humanities, arts and social sciences on the other. The EC Expert Group on Assessment of University-based Research (EC, 2010) mapped the *primary* forms of communication in the major discipline groups as shown in Table 12.

Some fields (especially in the humanities) publish in monographs or books; others (notably the basic sciences) in journals. While in the biomedical sciences hardly any researcher publishes a book, historians publish about 60% of their research in books rather than journals. Applied scientists and engineers often communicate more via conference proceedings than through learned journals. In engineering, articles in books (ISBN) represent the strong tradition of publishing in peer-reviewed conference proceedings.

However, the picture is more complex and differences in publication behaviour have also been identified at the discipline and sub-discipline levels. Mutz et al. (Mutz, Bornmann, & Daniel, 2013), for example, noted great differences in particular *within* the natural sciences and humanities.

Table 12: Primary form of written communications by discipline group

	Natural sciences	Life sciences	Engineering sciences	SSH	Arts
Journal article	√	√	√	√	√
Conference proceedings			√		
Book chapters				√	
Monographs / Books				√	
Artefacts					√
Prototypes			√		

Source: Expert Group on Assessment of University-Based Research (2010)

Differences among scientific fields present a challenge for all research evaluations, but especially for those based on bibliometrics.

- In peer review-based evaluations, the problem is solved by using field-based panels and units of analysis. This generally means that different fields are not put into direct competition with each other at the level of assessment. The focus is on ensuring that all evaluation panels have a similar understanding of the assessment scales so that the final scores have the same meanings and are comparable
- Metrics-based evaluations try to overcome field differences in publication patterns – and the significant limits of bibliometrics in the matter - by

introducing a mix of measures, including the use of field-normalised indicators and a weight system, and eventually, by separating field-specific streams of funding. In relation to the latter, to be coherent, the fields defined have to be relatively homogenous in terms of publication and other practices. At the same time, they must not be so small and narrowly defined that there is little or no competition within each

The current evaluation methodology in Bulgaria shows **significant shortcomings** in its approach to field normalisation.

- It handles the issue *exclusively* by defining field-specific units of analysis, avoiding competition among the fields. In other words, it adopts the approach used in peer review-based evaluations in the context of a metrics-based evaluation – without the benefit of peer expertise to ensure a correct field-specific interpretation of the bibliometric data
- A consequence of this approach is that in the 2017 pilot evaluation, the final ranking of the analysis units occurs *at the level of scientific areas on the basis of arithmetic scores.* Therefore, the final scores are not comparable across the fields, which limits the informative value of the evaluation in terms of its capacity to identify strong and weak research fields in the Bulgarian system. It also risks locking in the existing hierarchy of institutions, even if the best in a field are not very good
- The categorisation of research in the scientific areas was improved in the 2017 pilot evaluation, bringing the fields up to 10. While this would be the absolute minimum number for a peer review-based evaluation, it is highly insufficient for appropriate field-normalisation of the bibliometric indicators
- There is no weight system for the bibliometric indicators to recognise the field-specific differences in publication forms, channels, citations etc. and no use of field-normalised indicators

4.2.2 Definition of the reference period

The **one-year referencing period** used in the Bulgarian PRFS (for all indicators) is **highly unusual and problematic**. On an annual basis, data cannot convey an appropriate comprehensive view on research performance or progress.

A major difference between peer-review-based and metrics-based evaluations is in the frequency of the evaluation, a factor that is closely related to the effort and (financial) resources required for the implementation of a peer-review-based evaluation. Metrics-based evaluations often take on the function of a monitoring system and are therefore organised on an annual basis. This does **not** mean, however, that the reference period (or 'reporting' period) in metrics-based evaluations is limited to one year. While the institutions are typically requested to report their data on an annual basis, internationally the norm is that the assessment itself takes into consideration research activities over a **longer time period** – typically three to four years prior to the evaluation. The data are aggregated (or in some cases, averaged) to provide a more comprehensive view on the intensity and quality of the research performance while monitoring progress, too. In PRFS specifically, there is also the need to handle yearly fluctuations in order to avoid significant changes in the annual funding allocations as well as a gaming of the metrics.

In PRFS, also the **effects of the fluctuations in the research funding and a gaming of the system** need to be taken into account. Significant fluctuations in the number of publications can be expected from one year to the next, especially in smaller assessment units. To avoid the risk that this will also create significant fluctuations in the funding levels, the pressure on the researchers to publish on a short-time basis will be particularly heavy. The risk is that this will lead to the well-known 'salami slicing' phenomenon, i.e. the publication of several small and often overlapping papers on a specific research project or idea rather than a single comprehensive article. In other words, quantity will be created at the cost of quality.

Finally, wherever citation indicators are used, a **'citation window'** needs to be taken into account, i.e. a time interval starting from the date of publication. Citation frequencies are highly field-dependent; bibliometricians consider a period of four to six years as appropriate in most science fields for an evaluation to capture sufficiently valid citations.

The current practice in Bulgaria of counting citations in the year that they appear in the literature and with no consideration for the year in which the cited article is published inevitably creates a significant advantage for research institutions employing a large number of senior researchers who continue to build on their past success, even in the absence of new publications.

4.2.3 The 'scientific output' indicators

The number of publications is a basic measure of scientific productivity. Publication in journals or other channels that are indexed in international databases is expected to reflect a quality factor and, as such, are justified.

Below we address the many challenges related to the output indicators, several of which were mentioned in the pilot evaluation reports.

- **Defining research outputs and data sources**

It is important to define in a consistent manner what constitutes an 'article' or 'publication' and 'monograph', etc. Precise definitions will enable the research institutions to be more accurate in their data submissions. In addition, a better definition of the accepted data sources for the publications (be they databases, repositories or publishing houses) is needed to ensure the quality of the data provided and, most important, to avoid gaming in the system. We have dedicated Section 0 to this issue.

- **Fairness in assessing research outputs**

Quality research productivity indicators should take into account the field specifics in relation to the type, channel and frequency of publications:

  – <u>Differences in type and channel</u> are taken into account primarily by including specific indicators. Each type of research output should be measured separately (except for monographs and books) to allow for the weighting of indicators in bibliometric-based evaluations or for analysis at the field level in peer-review-based evaluations. For the sake of fairness, the Bulgarian evaluation methodology should therefore, at least cover the major forms of communication in the scientific fields listed in Table 12, above, under the 'research outputs' assessment criterion

– Differences in publication frequency mainly relate to the time needed to produce a type of publication. These differences are taken into account through a weight system. Monographs and books, for example, are typically weighted by a factor of 5, as was correctly suggested in the 2017 pilot evaluation report

We suggest making the weights in the evaluation methodology consistent with those currently being applied in the research-related component of the HEIs' performance-based institutional funding system.

The main aim of weighting types of research outputs in bibliometrics-based evaluations is to achieve a balanced representation of all fields in the (aggregated) publication count-out. It is not a straightforward exercise and requires bibliometric expertise. The proposal in the 2017 pilot evaluation to apply a higher weight for monographs and books published by established international publishing houses for the natural sciences, medicine, and technical sciences suggests a misunderstanding concerning the use of these weighting systems.

In some PRFS, specifically those using the 'Norwegian model', a weighting is also applied to make a distinction between types of channels for the publication. We cover this in Section 4.3.3

- **The inclusion of non-scholarly outputs**

Another topic that emerged from the 2017 pilot evaluation was the need to take account of research outputs to the benefit of actors beyond the scientific community.

In some PRFS, a distinction is made between 'scholarly outputs' such as papers in peer-reviewed journals and conference proceedings and **'non-scholarly outputs'**, reflecting the different target audiences. Non-scholarly outputs are defined in the UK REF as "outputs that provide for societal or commercial use of research". Examples include commissioned reports or publications for wider audiences, as well as artefacts.

Non-scholarly outputs can have high relative importance in some scientific disciplines and be even more frequent than scholarly publishing. This is true in parts of the social sciences and humanities, as well as other fields such as medicine and agricultural sciences. However, in metrics-based evaluations, in particular, special care should be taken to **define the outputs in a very precise and restrictive manner** to avoid gaming and to ensure the usefulness of the indicator.

- **How to handle co-publications**

Whenever productivity indicators are constructed for the purpose of the PRFS, the issue emerges of how to handle co-publications. Depending on how the productivity indicators are constructed, they can either **stimulate or discourage** research collaboration. Different countries take different approaches according to the PRFS objectives and the characteristics of the research system. A major factor to take into consideration here is the potential to play the system.

The options are to 'double-count' co-publications (i.e. the publication counts as a whole one for each author) or to 'fractionalise' them (i.e. each author is allocated an appropriate fraction of credit for the publication). The **intermediate solution is to distinguish between cases**, i.e. the different authors involved, from a geographical or institutional perspective, or both. Co-publications with authors abroad, for example, should not be fractionalised if the aim is to stimulate international collaboration (or to avoid creating incentives *not* to collaborate internationally). In the context of the fragmented Bulgarian research system, the option would be double-counting co-publications between researchers in research institutes and HEIs to stimulate collaboration in research – or even setting a higher weight on such co-publications.

Double-counting co-publications within a single unit of analysis, however, is likely to cause gaming and is therefore normally not permitted.

Co-authorship practices differ widely across the fields. The average number of authors may differ, as well as the norms with regard to the sequence of authors and the importance of some positions, e.g. the first or corresponding author. In peer-review-based evaluations, the issue can be overcome thanks to the expertise of the peers and the request for additional (qualitative) information. In metrics-based evaluations, the only option is to **establish clear criteria**, in collaboration and agreement with the scientific communities. Below, we give an example of how Estonia deals with publications by a high number of co-authors.

The approach to co-publications in Estonia

Publications are only attributed to the institutions if the author mentions the affiliation in the publication. Publications that can be attributed to more than one institution will count once for each of them.

There is, however, an element of fractionalisation in that publications with more than 100 authors will be given only half of the weight, while publications with more than 1,000 authors will be given a third of the weight.

Source: Debackere, et al., 2018

4.2.4 The 'scientific impact' indicators

The current use and design of the 'scientific impact' indicators is **highly problematic**.

The Bulgarian PRFS includes four citation-related indicators: a citation frequency indicator counting citations; two indicators counting publications in impact factor journals (JIF), of which one relates to the top 10 % JIFs; and one indicator averaging the h-indices of the research staff. As mentioned above (Section 4.1) above, the high number of citation-related indicators is an expression of the PRFS' emphasis on 'excellence' in research.

There are various issues, ranging from the lack of field-normalisation and the use of an appropriate citation window, to the need for a delimitation of the sources for citation data, currently indicated by the vague term "the science literature" (covered in Section 0). From the information provided in the pilot evaluation reports, the impression is that there is also a need for a precise definition of the term 'citation', i.e. whether only citations in scholarly sources or also references in the media should be accounted for.

In the sections below, we detail the major issues arising, i.e. the field normalisation of the citation frequency indicator and the appropriateness of using JIFs and h-index indicators in a research-performance assessment.

- **The citation frequency indicator**

The citation indicators most commonly used in PRFS are:

- total number of citations
- total number of citations compared to the average in the field
- proportion of publications among the most cited in the world in the same field

The first of these indicators, which is currently used in the Bulgarian evaluation methodology, is not field-normalised and therefore cannot be used to compare publications from different fields. The two other indicators are examples of **field-normalised citation indicators**. The 2018 PSF MLE on PRFS (Debackere, et al., 2018) states: "With caution, these can be compared across fields, but a very detailed and sometimes problematic classification is often needed, e.g. distinguishing between neurosciences and clinical neurology." van Raan (van Raan, 2014) regards the share of top-cited articles as an important indicator because it takes into account the highly skewed distributions of citations and thus does not give an – often – – distorted picture that the use of average values might provide. However, it is important to make sure that the top 10 percent of articles are measured *against the specific definition of the research area or field*. Otherwise, it can be grossly unfair to researchers or research units in areas with a lower 'citation density'.

Field normalisation in the context of a citation analysis requires substantial capability and experience to use advanced, state-of-the-art bibliometric techniques. However, the complexity of citation analysis goes beyond the consideration of fields, which explains also why **citation analysis is an expert domain**. The number of citations depends on several factors, such as the year of publication, the type of publication, the propensity for publication and for citations in the different fields, and coverage of the fields in the database used for the measurement. For example, the Web of Science (WoS) document types 'article', 'letter' and 'review' should not be directly compared with each other because review articles tend to attract many more citations than ordinary research articles, while editorials tend to get cited much less frequently than ordinary research articles (Wouters, 2015). A distinction should also be made between the authors of the citations because of the high potential for gaming. With this in mind, author self-citations are excluded from the calculation of citation impact indicators in some PRFS.

The 2018 PSF MLE on PRFS report (Debackere, et al., 2018) refers to the Leiden Ranking: http://www.leidenranking.com/ as "an interactive source of bibliometric information in which one can study the typical well-established field-normalised citation indicators by selecting particular countries and universities." The site offers also technical explanations for the indicators.

- **The Journal Impact Factor (JIF) indicators**

The JIF is an easily available indicator that is widely used in research assessment. However, the bibliometrics research community[11] has repeatedly published recommendations **not to use** these indicators as "quick and dirty measures" for the quality of research. Nevertheless, the misuse of these bibliometric indicators has become common practice in several countries and, we fear, in Bulgaria, too.

The JIF measures the average number of citations to articles in a certain journal within a certain time period. The 2018 PSF MLE on PRFS report (Debackere, et al., 2018) stresses: "While the JIF, and the alternative, SNIP (based on Scopus), may be valid indicators of journal impact, they **cannot be used to assess the citation performance of individual publications or authors**."

The average citation impact of a journal is only a weak predictor of the citation impact of individual publications. It cannot simply be assumed that articles published in high-impact-factor journals are high-impact articles. The assumption that each article published in a specific journal would be cited equally is wholly unsupported. Outstanding and original work can be found published in journals of low-impact factor and vice versa. In addition, the use of JIF indicators in performance assessments risks creating perverse behaviour in the conduct of research. Three national academies (Académie des Sciences, Leopoldina and Royal Society) noted in a recent statement: **"**There is growing concern that such 'IF pressure' on authors has increased the incidence of bad practice in research and the 'gaming' of metrics over the past two decades, in particular in those disciplines that have overemphasised impact factors" (Academie des sciences, Leopoldina, Royal Society, 2017).

- **The h-index indicator**

Another indicator often used informally is the h-index (or Hirsch index). Possibly because of its simplicity, the h-index has recently become a popular bibliometric indicator among amateurs. However, its use in evaluations has significant reservations and thus in our opinion should **not be used in the context of an evaluation**.

- It is almost never field normalised while there are large differences in citation density among and within research fields, rendering h-index values inappropriate for comparisons between specific individuals,

[11] These include the San Francisco Declaration on Research Assessment (ascb.org/dora), which was initiated by the American Society for Cell Biology and now has more than 13 000 signatories across the world, the Leiden Manifesto for research metrics (Hicks, Wouters, Waltman, de Rijke, & Rafols, 2015), and The Metric Tide report (Wilsdon et al, 2015). [wrong font in reference and full point after al.]

groups, or research units (e.g. a high h-index in the life scientists is 200, among physicists it is 100, and among social scientists 20-30).

- It is difficult to aggregate the indicator from the individual to the group or institutional level.
- It disregards the contribution of co-authors.
- It is database-dependent (e.g. WoS versus Google Scholar)
- The dynamics of the h-index imply that an author gets the highest score at or after the end of his/her career. The older and author is, the higher his/her h-index, even in the absence of new papers, which risks harming young researchers.

4.2.5 Delimitation of the data sources

A **precise definition** of quality sources for data collection is of critical importance in a PRFS, not only because it should guarantee the quality of the data provided, but also because it should avoid encouraging a proliferation of articles published in second-tier journals that aim merely to increase the number of articles published without ensuring scientific quality.

The Bulgarian national evaluation methodology indicates a range of data sources these indicators, shown in Table 13. This definition of sources for bibliometric data is problematic particularly for productivity and citation data. It comes as no surprise that it created considerable problems in the 2016 and 2017 pilot evaluations.

Table 13: Currently accepted sources for bibliometric indicators in the Bulgarian PRFS

Indicator	Source
Number of science publications	Global secondary literary sources
Number of citations	Science literature
Publications in journals with impact factor	Web of Science or Scopus
Publications in top 10% of impact factor journals	Web of Science of Scopus
Averaged h-index	Scopus

As in all evaluations in the context of PRFS, the challenge is how to overcome the well-known limits of the commercial WoS and Scopus databases in terms of linguistic and scientific coverage while maintaining the necessary assurance of collecting quality data. Below we give a view of the approaches in the international landscape from that perspective, giving suggestions on how these could or should be applied in the Bulgarian evaluation.

The most important multidisciplinary bibliographic databases are the commercial WoS and Scopus, Google Scholar (GS) and Microsoft Academic (MA). The **WoS** and **Scopus** both have their well-known limits.

- Coverage of the scientific literature across subject disciplines varies significantly between these databases. Various studies note that Scopus offers better coverage than WoS (Wouters, 2015).
- Although Scopus has a broader coverage, the two data sources follow the same pattern in their representation of major scientific areas. The literature shows that this limited coverage of articles and proceeding papers in social sciences and humanities (SSH) is partly due to incomplete coverage of the international journals in SSH and the limited or no coverage of national disciplinary journals, and partly due to their limited coverage of scholarly books, which are important in SSH (Debackere, et al., 2018)
- In addition, there is a substantial language bias in both commercial databases towards publications in English. This hinders the assessment of local societally relevant research and limits the potential to assess those disciplines where the use of the national language is more frequent, notably in the humanities, social science and the health sciences.

GS and MA are generally found to outperform both WoS and Scopus in their coverage of scientific literature and are free of use. However, they are often criticised for their lack of quality control and transparency and for unstable search results. Thus, they have not yet become standard data sources for professional bibliometrics and their use in the context of PRFS is **not** recommended.

Internationally, PRFS tries to overcome the limits of the commercial databases by **distinguishing between citation databases and article databases** as sources for specific indicators. It allows for a more limited use of WoS and/or Scopus, i.e. for the collection of citation data only.

- Citation databases are bibliographic databases where publications are linked whenever they refer to each other in the reference list. This method demands that the full reference list of each publication is recorded. Citation databases are the most detailed on publications, as they also include links in the citation network. *Citation indicators are only possible if this method (citation indexing) is used.* Currently, this implies the potential use of WoS and/or Scopus only.
- Several bibliometric indicators, mainly those representing productivity, research profiles (relative composition of disciplinary fields) and collaboration in publications, do not depend on citation indexing. In these instances, international article databases can be used. There are many discipline- or field-specific services. These include the PubMed[12], DBLP[13], SSRN[14] or arXiv[15] services. The first two contain publication metadata only and have very systematic coverage of their respective domains. The SSRN and arXiv are examples of field-specific open access (OA) repositories.

  An important limit to many of these international article databases is the lack of guarantee on the quality of the publications provided by the WoS and Scopus databases through their definition of quality criteria for the journals to be indexed.

In some countries and fields of research, the community has reacted to the limits of the available article databases and created **'databases of approved sources'**, thereby also overcoming limited coverage of national scientific journals and journals in specific fields in the commercial databases. The most important example of a database of sources at the field level is the European Reference Index for the Humanities (ERIH), which was created by the Standing Committee for the Humanities of the European Science Foundation. The concept was to add value to output from the SSH domains by grouping journals into categories or quality levels, based on peer-review (Wouters, 2015). National databases of approved sources/channels have been developed in various countries, in some cases including not only approved journals but also publication channels, i.e. publishing houses. Prime examples are the VABB-SHW database in Flanders,

[12] PubMed Central, http://www.ncbi.nlm.nih.gov/pmc/, a service of the National Library of Medicine in the National Institutes of Health, US
[13] DBLP computer science bibliography, http://dblp.uni-trier.de/
[14] Social Science Research Network, http://www.ssrn.com/en/
[15] http://arxiv.org/help/general, operated by Cornell University

Belgium, and the Current Research Information System in Norway (CRIStin). Both are directly used in PRFS.

The process for creating these registers typically involves the same definition of quality criteria as those used in ERIH (see below) and setting up a national committee of scientific experts responsible for the selection of the journals and publication channels and for updating the register, normally on an annual basis.

Quality criteria for publication channels in ERIH PLUS

As of 2014, ERIH has evolved into ERIH PLUS, a dynamic register of approved peer-reviewed journals also covering the social sciences. To be included in ERIH PLUS, journals must meet the following minimum requirements:

- Established procedures for external peer review. The concept of external peer review refers to various forms of editorial procedures that differ between academic fields and scholarly journals, and which indicate that the manuscript has been evaluated by one or more independent experts on the subject matter.
- Academic editorial board (or an equivalent), primarily consisting of scholars from universities, research institutes etc.
- Valid ISSN code, confirmed by the international ISSN register
- Publication of all original articles with abstracts, as well as author and address information, in English (or in another language relevant to the field)
- International or national authorship, i.e. "less than two thirds of the authors published in the journal are from the same country", or "more than two thirds of the authors published in the journal are from the same country"

Scientific journals with local authorship, i.e. "more than two thirds of the authors published in the journal are from the same institution", are **not** included in ERIH PLUS. The concept is that independent peer-review cannot be expected to function satisfactorily for a journal that primarily represents an institution's own researchers.

Some countries also went over to categorisation of the 'publication channels', based on the importance that local scientists attribute to the specific 'publication channels' in their field. The categorisation was then used in the PRFS for a weighting of research productivity scores by type and channel. This approach is called 'the Norwegian model'.

The Norwegian model

In the Norwegian model, publications are given weights according to Table 14. In one dimension, three main publication types are given different weights: articles in journals and series (ISSN), articles in books (ISBN) and books (ISBN). In another dimension, publication channels are divided into two levels in order to stimulate publishing in the most prestigious and demanding publication channels within each field of research.

'Level 2' is the highest level and includes only the leading and most selective international journals, series and book publishers. There is also a quantitative restriction, since the publication channels selected for Level 2 can only represent a total of up to 20% of the world's publications in each field.

The weighting of publications by type and channel is shown in Table 14.

Table 14: Weighting of publications by type and channel in the Norwegian Model

	Level 1 (normal)	Level 2 (20 percent)
Article in ISSN title	1	3
Article in ISBN title	0,7	1
Book (ISBN title)	5	8

Source: (Debackere, et al., 2018)

An increasing number of countries are installing **national Current Research Information Systems (CRIS)** to collect and process the large quantities of data needed for a PRFS, as well as for storing local or national bibliometric databases. National CRIS are also a way to maintain a high quality of input data. As mentioned in the H2020 PSF Peer Review and the pilot evaluation reports, they enable a less-tiresome transfer and updating of the required information by the research-performing organisations.

Thus, there is an important case for the use and updating of the Bulgarian Research Information System (BulCRIS) to facilitate and quality-guarantee the data collection and management process for the PRFS. The use of a CRIS, which constitutes the European standard for research information systems, rather than another information system, would ensure compatibility of Bulgaria's system with those used in other EU countries. It is on the European agenda to establish internationally integrated CRIS with comparable data.

4.2.6 Summary and recommendations

The evaluation methodology is in need of major improvements from a 'technical' perspective, i.e. related to the quality of the specific indicators used. We believe that these improvements are critical if the evaluation is to make a fair and robust assessment of research performance in Bulgarian research institutions. **We recommend that the Bulgarian authorities make the necessary adjustments before the evaluation methodology is used for the distribution of institutional funding for research.**

The evaluation methodology needs significant improvements in its approach to field normalisation. The field categorisation should be refined, accompanied by better coverage of the relevant publication types and channels, a weighting system for the bibliometric indicators recognising field differences, and the use of advanced field-normalised indicators.

The one-year reporting period used in the Bulgarian PRFS (for all indicators) is highly unusual and problematic. **We recommend the use of a four- to five-year reference period for all indicators.**

The pilot evaluations in 2016 and 2017 pointed to multiple problems for the collection of quality data related to research outputs. Many of these problems seem to relate to the lack of a clear description of the evaluation methodology for organisations participating in the evaluation to consult in their data-collection and submission process. **Clear definitions of the terms used, delimitation of the type of products or activities admitted, and a selection of the data sources allowed are key measures to overcome this problem.**

There is room for improvement in the use of data on research outputs. **We recommend in particular to adopt the intermediate solution for the handling of co-publications, distinguishing between cases and defining clear criteria in collaboration and agreement with the scientific communities.**

Especially problematic is the current use and design of the 'scientific impact' indicators. Field-normalised indicators need to be designed for the citation analysis, accompanied with an appropriate citation window, a precise definition of the term 'citation', and an improved delimitation of the data sources. Impact factors cannot be considered a proxy for the quality of a publication and the use of these indicators presents a high risk of playing the system and of allocating funding to research that is below the standards the PRFS aims to improve. The h-index indicator presents serious limitations and its use in evaluation risks harming younger scientists. Most important, both the IF and the h-index not only fail to reflect correctly the quality of research but may also hinder appreciation of the work done by excellent scientists outside the mainstream. In the context of a PRFS, both types of indicators are oriented towards rewarding existing hierarchies, mainstream research, and senior scientists. **It is our opinion that the use of the JIF-based indicators and the h-index indicator is ill-advised. We recommend that these indicators be withdrawn from the evaluation methodology. Advanced citation analysis based on actual citation counts per article is the preferable option.**

The identification and selection of quality sources for the collection of data on bibliometric indicators is of critical importance, not only because it should guarantee the quality of the data provided, but also because it should avoid encouraging a proliferation of articles published in second-tier journals that aim merely to increase the number of articles published without ensuring scientific quality. A distinction should be made between 'citation databases' and 'article databases'. **We recommend defining WoS and Scopus as the only permitted sources for citation data and to select data sources on articles based on their internationally recognised quality. Wherever possible, databases that set quality criteria for the indexed journals or 'databases of approved sources', such as ERIH, should be used. The Bulgarian authorities may also want to consider creating a Bulgarian 'database of approved channels'.**

Evaluations are resource-intensive exercises, both for the assessed institutions and the public authorities in charge. **Thus, there is an important case for using and updating the Bulgarian Research Information System (BulCRIS) to facilitate and quality-guarantee the data collection and management process for the PRFS.**

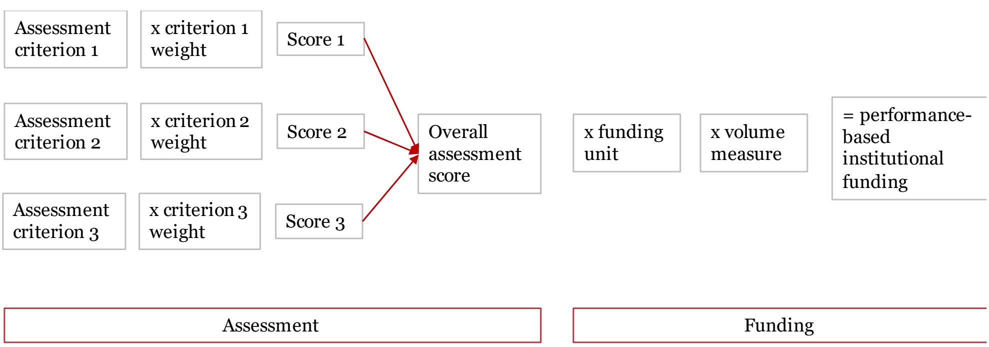
PRFS are complex systems and their design can have significant long-term effects on the conduct of research and the functioning of the research system in general.

The difficulty and sensitivity of an adequate design for a PRFS should not be underestimated. This concerns the indicator mix in general, but especially the design of citation indicators. Citation analysis is highly complex and an expert domain. A general observation in this context is that the evaluation methodology insufficiently distinguishes between methods used in peer-review-based and (biblio)metrics-based evaluations. These two evaluation models have their specific strengths and weaknesses and differ in their approach to the numerous challenges in evaluating research, such as field normalisation. Methodologies and approaches that may work in one model cannot simply be adopted in another one. **We recommend that the Bulgarian authorities take stock of the experiences abroad and make more use of external professional expertise. We especially recommend seeking the support of bibliometric experts for the construct of field-normalised or field-independent citation indicators.**

4.3 The funding component of the PRFS

The results of the assessment feed into the second component of a PRFS, a funding formula. This is an algorithm for allocating institutional funding for research among the research institutions, based on performance. Key components are the funding unit, the volume measure, and the score and weight systems linked to the indicators and assessment criteria (Figure 10).

Figure 10: How a PRFS allocates funding to a research institution



Source: (Debackere, Arnold, Sivertsen, Spaapen, & Sturn, 2017)

In this section we first cover the use of **minimum threshold levels** to identify the research units and (parts of) institutions that are entitled to participate in the PRFS, then describe the **volume measures** by which the size of a unit of analysis is taken into account for the calculation of the scores, and ultimately the funding allocation. The **score and weight systems** for the calculation of the funding formula are the topics of the next sections, followed by a description of the international approach to decision-making on the position of the PRFS in the overall **funding mix**. We summarise our main considerations and formulate our recommendations in Section 4.3.6.

4.3.1 The use of minimum threshold levels

In the current system in Bulgaria, all HEIs are considered 'research organisations' and are therefore entitled to institutional funding for research. 'Research activity' is a criterion in the HEIs' performance-based funding for education and in principle, all HEIs are entitled to participate in the performance-based research funding system.

The current debate in the country is on the extent to which scientific research funding should focus only on HEIs that actively conduct research, seeing the particularly low level of research activity in the HE sector (see Section 2.2.3, above). Recent policy documents in Bulgaria suggest that there are different opinions on the matter. The Amendment to the Higher Education Act, adopted in 2016, indicates that all HEIs are expected to conduct research. The 2014 HE Strategy proposed the categorisation of the HEIs in four groupings, one of which 'research universities'; the 2017 National Strategy for the research system took up this idea and indicated "the scientific organisations and the *research* universities" as the organisations for which the PRFS would apply.

No concrete indications are given on the criteria that would allow for the identification of such 'research universities'. The clear intent, however, is to have the results of the performance assessment in the PRFS decide on which HEI would gain the status of 'research' university – and therefore be entitled to participate in the PRFS in order to gain additional institutional funding for research. This raises questions on the **purpose of the evaluation component** in the PRFS and on the extent to which a metrics-based evaluation in the context of a PRFS can adequately provide the required information for a fair and adequate decision-making on the matter.

In most countries, research-performing institutions that are entitled to receive (performance-based) institutional funding for research are defined at the central level, based upon a historical 'division of labour' in the knowledge economy and/or decisions taken by the Ministry of Education or another research governance body. Threshold levels are defined mainly to delimit the **characteristics of the institutions' units of analysis** that will be entitled to participate in the performance assessments.

In a PRFS assessment process, the **units of analysis** are field-defined research units which may organisationally be equivalent to research groups, departments, faculties or entire institutes. Research groups are the ideal unit of analysis in a PRFS as they allow for the identification of 'pockets of excellence'. In some countries, for example in Portugal and Slovenia, the units of analysis are defined at the level of research groups with the specific objective of fostering interdisciplinary research as well as collaboration in the research community. Slovenia allows for the formation of units of analysis across departments in the universities; the Portuguese PRFS allows for cross-institutional research groups. (Debackere, Arnold, Sivertsen, Spaapen, & Sturn, 2017) Nevertheless, the tension between complexity and practicality means that in practice, units of analysis are defined at a more aggregated level following the institutional structure. Peer review-based evaluations are typically done at the level of departments; metrics-based evaluations aggregate the data at the level of faculties or entire institutions (OECD, 2010).

Common practice is to define **minimum threshold levels for the units of analysis**. Drivers and characteristics depend on the evaluation method. Both have their pros and cons in terms of the potential 'gaming' they might induce. Important from this perspective is that counter-measures are included in the PRFS itself to limit these negative effects.

- In bibliometrics-based research assessments, thresholds are defined mainly to ensure the minimum number of data that is needed for robustness and validity. Below such a minimum, it becomes harder to identify statistical outliers and a single output can decisively skew the overall result. The thresholds are normally expressed in terms of research productivity, i.e. a minimum **number of research outputs**. *Fifty outputs a year* are a commonly used rule of thumb for a meaningful bibliometric analysis to take place. In Belgium/the Flanders, a minimum threshold is set at 1 000 publications in 10 years combined with at least 65 doctorate diplomas awarded over 4 years
- In peer review-based evaluations, the main driver is the need to limit the number of units of analysis and therefore costs of the assessment system. Other drivers may include the desire to incentivise smaller research performers to grow to a level where inclusion in the assessment is possible. Thresholds for the units of analysis are typically defined in terms of their size, i.e. a minimum **number of full-time equivalent (FTE) researchers**. The Dutch Standard Evaluation Protocol (SEP), for example, identified a minimum threshold level of *10 FTE* researchers together with some other criteria, as described below. This threshold was applied in the 2017 pilot evaluation in Bulgaria (based on number of researchers rather than FTE)

Conditions for the definition of the units of analysis in the Dutch Standard Evaluation Protocol (SEP) 2015-2021

In the Netherlands, the boards of the research-performing institutions (i.e. the universities, the NWO and the Academy) take full responsibility for the assessments in their own institutions. They are also responsible for seeing that every unit within their institution is assessed once every 6 years, for the overall scheduling of the assessments at their institution, and for giving notice of pending and concluded assessments.

The boards must also take a number of specific procedural decisions; this includes the decision on which research units will be assessed as a group by a single assessment committee. For example, a board may decide that the assessment will concern a research group, a research institute, a research cluster or the research carried out within a faculty.

The evaluation protocol defined at the national level sets out the general conditions for the definition of these units of analysis:

- The research unit must have its own clearly defined strategy and be sufficiently large in size, i.e. *at least 10 research FTEs* among its permanent academic staff, including staff with tenure-track positions and *not including PhD candidates and post-docs*. This merely indicates the minimum number, however; larger units are preferable.
- The research unit subject to assessment should have been established at least three years previously. If groups of a more recent date are to be assessed, their self-assessment should indicate their stage of development so that the assessment committee can take this into account when considering the 'viability' criterion.

- The research unit should be known as such both within and outside the institution and should be capable of proposing a suitable benchmark in its self-assessment. The benchmark would preferably be an international one.

Source: (VSNU, NWO, KNAW, 2014)

Only a few countries explicitly define threshold levels or eligibility criteria because of the lack of a legal base. Examples are Norway, Estonia and Croatia. These three countries take a common approach. There is a **two-stage** process whereby first the eligibility to institutional funding is decided upon and then, in a separate exercise, the actual size of the funding is defined by means of a performance assessment (metrics-based). However, they differ in terms of **method, criteria** and **scope** for the decision making on the eligibility for funding:

- In Norway, the Research Council Norway (RCN) bases its advice to the Ministry of Education upon available strategic information. Eligibility criteria are the level of research output and share of competitive funding and contractual research income in the institute's budget, as well as number of FTE scientists. The focus is on research institutes that have a function of government labs. A positive result implies that the institute will become part of the group of institutes and HEIs monitored, evaluated, and supported by RCN - and eligible for PRFS funding
- In Estonia and Croatia, the decision is based upon the outcomes of a peer review-based evaluation and the criteria focus on the capacity of the institution to conduct societal-relevant, quality research. It has the characteristics of an accreditation assessment: the results are valid for a limited number of years (5 years in Croatia and 7 years in Estonia) and the assessment concerns all research institutes and HEIs. A positive result grants the right to PRFS funding and to PhD programme(s)

Decision-making on eligibility for PRFS-funding in Norway

The Norwegian research system is made up of universities as well as a large number of research institutes that are considered to serve individual sector ministries. The Research Council of Norway (RCN), a combined research council and innovation agency, is responsible for the stewardship of the universities and research institutes through evaluation, special funding instruments and a PRFS.

The institute system contains scientific research institutes, RTOs and government labs grouped in 'arenas' with a specific ministry in charge. RCN recommends to the Ministry of Education and Research which specific institutes perform "sufficient research of sufficient seriousness" to be admitted to the RCN 'stewardship' and therefore gain access to the PRFS. There are a number of general criteria and four specific ones:

- Income from national and international commissioned projects must represent at least 25% of the total R&D income
- Scientific publishing (i.e. publication points per FTE) must at least be one-third of the average in the institute's arena
- The institute must have at least 20 FTE researchers
- The institute's competitive income (e.g. from RCN and EU) must at least equal 10% of total R&D incomes.

About 50, mostly small, institutes are excluded in this way. The Ministry takes the final decision, case by case.

4.3.2 The use and definition of a volume measure

Another fundamental component of a PRFS is the criterion used to take account of the size of the unit of analysis in the funding formula, i.e. the '**volume measure'** in terms of researchers involved.

Internationally, the definition of 'researcher' differs, depending on the national context and its needs (and in the case of the RAE/REF in the UK, on the general design of the evaluation and its purpose). In most countries, however, the size of research organisations from a human resources perspective is defined in terms of number of **FTE** researchers. For the calculation of the FTE number, the characteristics of the employment in the research institution are taken into account, such as part-time or full-time employment. PhD students are typically excluded and in systems where research staff can hold a position in more than one institution, such as in the Czech Republic, the 'full time' is typically divided among the employing institutions (this was an issue mentioned in the 2017 Pilot Evaluation report).

In the case of HEIs, the 'full time' calculation requires defining the boundary between researchers and teachers - since many but not all academics do both. In other words, not only the degree of employment is considered, but also the time spent on research as compared to education. There are two options:

- The preferred solution is to define a teaching-research ratio for the academic staff members. In some countries, the amount of time that academic staff dedicates to research versus teaching is defined in the individual contracts of the academic staff members with the HEIs. In other countries, the community reached an agreement on the 'average' share of time to be accounted for as 'time for research' - typically between 40 and 50%.
- Another (less desirable) option is to define a minimum number of publications per researcher – per year or over the assessment period (typically 5 years). For example, both the UK and the Italian PRFS set the requirement on *one publication per year for a full-time researcher*. In both countries, young researchers/technologists are expected to produce a more limited number of research products, depending on the date of hiring; reductions are also foreseen in cases of justified absence due to illnesses or parental leave. An issue with this publications-based approach is that it risks creating a disadvantage for scientific fields that have a lower publication propensity (see Section 4.3.3, below).

Some countries like Italy avoid the use of volume measures in the context of PRFS and use **size-independent indicators**. Size-independent indicators calculate the institution's share of the total in the national (field-specific) community rather than number, e.g. the 'share of PhDs awarded in the country in the field', or the 'share of state external research funding income in the field'. An advantage is that it sets the performance of a unit of analysis firmly within the context of the field in the country. An important disadvantage is that it risks over-awarding the larger institutions, thus locking-in existing institutional hierarchies in the system.

In Bulgaria, the current evaluation methodology uses the **'number of research staff'** as a volume measure for all indicators, in the case of the external funding indicators combined with the research staff's average gross annual employment salary. The definition of 'research staff' provided in the 2015 Regulation means that all academic staff members, including PhD students, are considered 'researchers', independently of their research activity. In a context where research activity is very limited in the higher education sector, this definition of 'research staff' is highly inaccurate, raising questions on the fairness of the funding formula. It also risks creating a misleading view on the true research capacity in the country, i.e. the number of active researchers in the various fields.

The second volume measure used in the Bulgarian system for the external funding indicators, the '**average gross annual employment salary'**, is problematic as it creates an advantage for organisations that have research staff with the lowest salary levels; it therefore risks acting as a disincentive to raise these salary levels, in contrast to the fact that the 2017 National Strategy set increases in researcher salaries as a policy objective. The recommendation is to use the number of research staff for all indicators - and in the near future, the number of FTE researchers.

4.3.3 The score system in the funding formulae

A key decision to be made in the design of a PRFS is the approach used for the score system, i.e. the calculation of the scores against indicators and assessment criteria. The objective of a score system is to assign nominal scale values to the performance of a unit of analysis in order to ensure comparability of the scores reached against the different indicators.

The approach to this process is determined in a first instance by the choice of the method for the evaluation. In peer review-based systems, it is based on a qualitative assessment by the peers who consider in an aggregated manner the performance of the unit of analysis against the different indicators to then define the position the performance of the research unit in a performance ranking system.

Metrics-based systems, instead, require the definition of a score system at the level of the indicators to ensure that all indicators have an **equal influence** on the calculation of the score against a specific assessment criterion. Internationally, the practice differs. Some countries such as Sweden set the value reached by the unit of analysis against the average in the country (around 0, which is the average); other countries such as Italy and Norway consider the share of the overall value at country level (eg the share of national publication points or EU research income).

Set against the international practice, the current approach in the Bulgarian PRFS to define the scores against the indicators by taking only the volume values into account is highly unusual. Essentially, we can speak of an absence of a proper score system. The inevitable result is that indicators have a higher or lower influence on the score against an assessment criterion depending on the typical size of their 'value'. The 2017 pilot evaluation showed, for example, that the number of citations was the most influential indicator for close to all units of analysis because the corresponding number of 'points' assigned for this indicator was typically the largest.

4.3.4 The weight system in the funding formulae

Another key decision regards the weights to be attached to the specific indicators and assessment criteria. The purposes slightly differ: while the common purpose is to make explicit the relative importance of the indicator or criterion from a policy perspective, weights attached to specific indicators in metrics-based PRFS also intend to obtain field normalisation. It is the combination of criteria and weights that allows complex systems to provide an all-round assessment while still prioritising the most urgent failures in the system.

In the current design of the evaluation and funding system in Bulgaria, **no weights** have been defined for any of the three assessment criteria. The final score of the unit of analysis is reached by adding up the scores for each assessment criterion. There are also no weights defined for any of the 17 indicators, except for the indicator "B1 - no of publications in the top 10% of impact factor journals" which has a weight of 10. The scores for the three assessment criteria are therefore obtained by merely adding up the scores for the individual indicators.

This lacking definition of weights is a further illustration of the limited use of the PRFS as a policy tool, in sharp contrast to the normal practice internationally.

Table 15 shows the variations in importance attributed to criteria and indicators in various countries, illustrating the influence of the policy objectives in the PRFS. The PRFS in the UK, New Zealand and the Czech Republic stand out for the high weight attributed to the results of the research quality assessment, while the systems in Finland, Norway and Belgium (the Flanders) attribute high importance to effects on the research system (internationalisation, PhD education and the institutional environment). Italy stands out for the weight set on innovation-related outputs and activities. Denmark and Sweden attribute higher than average weights to the capabilities of the universities to attract external funding for research.

Table 15: Weights attributed to indicators and assessment criteria for the funding allocation based on the PRFS

	Research quality	Internationali sation	PhD students / awarded	Institutional environment	Innovation outputs/ activities	Impact	External funding	Other
BE – FL (2011)	39%		35%					27%
Czech Rep.(2013)	85%				15%			
Denmark (2012)	45%		18%				36%	
Finland (2013)	38%	9%	26%				26%	
Italy (2014)	31%	12%	6%		38%		6%	6%
Norway (2014)	30%	20%	30%				20%	
Sweden (2012)	50%						50%	
UK (England) (2014)	65%			15%		20 %		

Source: (Arnold, et al., forthcoming 2017)

In a few countries, **additional adjustments to the funding quota** are made to concentrate funding in fewer places or to compensate specific fields of science (specifically the 'hard' sciences) for the higher costs of doing research. Both practices are rare.

- While rewarding performance is an intrinsic characteristic of all PRFS, only in a few countries (the UK and Finland) does this selective distribution of funding deliberately also aim at a concentration of resources. This is done by skewing the funding formulae towards high-performing institutions.
- In a few countries (Croatia, UK, Sweden), funding quota are weighted explicitly to take account of the different cost levels associated with different disciplines. In some fields (typically the 'hard' sciences), institutional costs for research are inherently higher than in others (e.g. social sciences and the humanities). The 2018 H2020 PSF MLE on PRFS report (Debackere, et al., 2018)) links the practice in Sweden and the UK of explicitly calculating 'field-normalised costs' to their focus on quality rather than productivity in the evaluation. In most countries, instead, productivity is an important component in the funding formulae; seeing that the 'expensive' disciplines are also those that publish most, these countries create an intrinsic compensation for the higher costs.

If it is to be transparent, accepted by the academic community and useful for strategic decision-making, it is important that the PRFS **strictly separates assessment from funding.** This means that for each indicator, the 'clean' scores reached by the units of analysis (i.e. before applying weights or using volume measures) should be identified and made identifiable to the assessed organisations. It also means that adjustments of the funding quota to the benefit of certain groups of actors or fields of science as mentioned above should be done explicitly in the funding formula.

4.3.5 The share of the PRFS in the funding mix

Current policy documents in Bulgaria do not provide any indication of the intended share of the performance-based funding of research within the budget for the institutional funding of research and within the overall research funding budget. These are important omissions that affect aspects of the PRFS design.

The key question is to what extent funding for research should be allocated based on competition. This relates to the share of institutional versus project-based funding and within the institutional funding component, the share that is steered through the PRFS. The most common understanding of institutional funding is that it needs to provide **continuity, stability, sustainability and resilience for institutional development**, and that a long-term shortfall in institutional funding leads to a 'hollowing out' of research organisations (Georghiou, 2014). Institutional funding is infrastructural in nature; it provides a basis for strategy and planning and for maintaining capacity to do research.

Different countries choose different **balances between institutional and project-based funding** of research. The pattern is very diverse in Europe and seems not to be influenced by geographical position nor the size of the country, but is rather driven by the nationally developed strategies in R&D policy (Reale, 2017). Generally, governments fund the majority of R&D in the higher education and research institute sector through institutional rather than project-based funding, even though the trend has been for the ratio of external, competitive project funding to institutional funding to rise (Lepori, et al., 2007).

A recent EC study (Reale, 2017) shows that in only seven out of the 36 countries surveyed[16], the government distributed 50% or more of its R&D budget through project/programme funding in 2014. Bulgaria is in the second group of 5 countries[17] that distributed between 40% and 50%. In other words, based on this study, the **share of research budget distributed through institutional funding in Bulgaria is relatively low in the European context**. Two-thirds of the countries covered (24 out of 36) distribute a higher share of their research budgets through institutional funding.

When deciding on the **share of the institutional funding** governed by the PRFS, the following elements should be taken into account. (Debackere, Arnold, Sivertsen, Spaapen, & Sturn, 2017)

- The level of non-competitive institutional funding (ie not counting the performance-based elements) should enable the HEIs and research institutes to pay the 'infrastructural' and variable costs to do a reasonable amount of research autonomously

[16] Belgium, Czech Republic, Estonia, Ireland, Poland, UK and USA

[17] Greece, Finland, Portugal, Israel and Norway

- It is important to ensure research institutions have sufficient institutional funding to be able to pay the non-funded costs associated with winning external funding, since this almost never covers its entire cost
- The higher is the share of the performance-based funding in the institutional funding system, the higher the risk that unintended negative effects – including funding instability – will profoundly affect the R&I system. High shares in the overall funding system therefore set particularly high-quality requirements on the design of the performance-based funding system
- International data on funding and research performance in bibliometric terms do not support the idea that the bigger the proportion of external (quality-controlled) funding, the higher the quality will be of the research undertaken
- Competitive research universities are expensive institutions that must have adequate and sustained budgets and cannot succeed if funding fluctuates severely over time

Practices in the use of PRFS for the allocation of institutional funding substantially vary in the detail. However, in most institutional funding systems, a considerable proportion of the institutional funding remains unconditional and the introduction of PRFS resulted in only marginal changes to the funding mix. Most PRFS make up for a **small share of the institutional funding** for research, ranging between 10% and 20% of the total; only Finland, Denmark and the UK allocate more than 20% of the institutional funding through PRFS (43%, 31% and 22% respectively).

The size of the funding governed by the PRFS conditions the requirements set on the **quality and level of 'perfection' of the assessment methodologies**. Systems allocating a large proportion of institutional funding such as in the UK and Finland have to be methodologically very robust; those allocating a small proportion (e.g. Sweden, Norway) can be more rough and ready, for example in their treatment of inter-field differences in publication behaviour, while still being accepted by the community.

4.3.6 Summary and recommendations

In this section we covered the core elements of the funding component in a PRFS, i.e. the volume measure and score and weight systems, setting wherever relevant the approach in Bulgaria in the context of international practice.

An element that requires a policy decision *prior to the instalment of the PRFS* to reach a more concentrated allocation of the institutional funding as well as a more cost-efficient evaluation process, is the definition of minimum threshold levels that would entitle research units to participate in the PRFS. Such minimum scale level requirements contribute directly to reducing the incentives to fragment research activities, make more visible the lower performing parts of the system, allowing them to either improve or disappear, and provide an overall framework for addressing field-specific considerations. They can also form the basis for the restructuring of the Bulgarian research system as suggested in Section 0. In some European countries, such minimum threshold levels have been introduced successfully so as to combat research fragmentation and reduce PRFS and evaluation/assessment administrative costs, based on the size of the research units and/or the volume of the research outputs, eventually in combination with other indicators. **Before introducing a fully-fledged performance-based research funding system, we recommend the Bulgarian authorities finalise and refine the definition of minimum threshold levels for the inclusion of research units in the PRFS.** Lessons should be learnt from the threshold level used in the 2017 Pilot Evaluation, combined with an analysis of the characteristics of the units of analysis that registered for this evaluation.

A component of the funding formula in the PRFS which in our opinion needs urgent refining, is the volume measure. Volume measures are components of the funding formulae by which the size of a unit of analysis is taken into account for the calculation of the funding. Due to the definition of the 'researcher' position, the current use in Bulgaria of the 'number of researchers' as a volume measure is highly inaccurate. An improved definition would allow for a fairer distribution of the funding, based on the 'real' capacity for research in the institutions. It would also allow for a more accurate view on the research capacity in the country. **We recommend the use of 'FTE researchers' as a volume measure in the PRFS, based upon an improved definition of the term 'researcher' and an agreement in the research community on how to count the 'full-time' dimension in the HEIs.**

A key decision to be made in the design of a PRFS is the approach used for the **score system**, i.e. the calculation of the scores against indicators and assessment criteria. Set against the international practice, the current approach in the Bulgarian PRFS to define the scores against the indicators by taking only the volume values into account is highly unusual. This approach creates a 'random weighting' of the indicators for the calculation of the scores against the assessment criteria, determined by the typical size of their 'value'. It also implies that the performance of a unit of analysis against the different indicators cannot be compared, for example to establish strengths and weaknesses. It therefore inhibits a proper use of the evaluation outcomes to take 'corrective' actions and improve the units' research strategies, and considerably limits the transparency of the evaluation process. **We recommend the Bulgarian authorities to develop a score system that would ensure an equal influence of the indicators on the calculation of the scores against the assessment criteria, as well as enhance the strategic value of the evaluation outcomes and the transparency of the evaluation process.**

It is the combination of assessment criteria and weights set on indicators and criteria that allows PRFS to provide an all-round assessment while still prioritising the most urgent failures in the system. We see the current lack in weights linked to the indicators and assessment criteria in the Bulgarian PRFS as an additional illustration of the limited use of the PRFS as a policy tool, which is in sharp contrast to the practice internationally. In PRFS, policy goals should define not only the choice of the indicators but also the weights allocated to each of the assessment criteria, making explicit their relative importance. **Policy decisions need to be taken related to the weights of the different assessment criteria in the funding formulae *after* a revision of the indicators and a refined grouping of the indicators around assessment criterion.**

Current policy documents in Bulgaria do not provide an indication of the intended share of the performance-based funding of research within the budget for the institutional funding of research and within the overall research funding budget. These are important omissions that affect aspects of the PRFS design. **We advise the Bulgarian authorities to ensure the balance between competition, stability and restructuring. We recommend that the decision on the share of institutional funding governed by the PRFS should bear in mind that a large proportion governed by a PRFS sets particularly high requirements for the quality and robustness of the evaluation methodology.**

4.4 Evaluation at the individual researcher level

The 2017 National Strategy also suggests installing a two-component financial system also for individual researchers. Like the research institutions, individual researchers would undergo a 'periodic attestation', the results of which would drive part of their salary.

The aim is similar to the one for the PRFS at the institutional level, i.e. to obtain a higher funding of the individual researcher (ie salary increase) based on performance. The policy objective is to avoid brain drain and to make a scientific career more attractive, seeing the particularly low salaries and PhD scholarships in the country (see Section 2.2.4, above). It is unclear in the strategy as to which criteria will be used for this attestation and how this 'attestation' will be conducted (through metrics or peer review). However, the impression is that the (biblio)metric indicators that are defined in the 2015 Regulation will be used, seeing that these same indicators are also used in the performance-based funding system for education.

In a system that does not have high trust levels, the use of seemingly 'objective' indicator data to make drastic personnel decisions can be attractive. However, from the point of view of legal rights and fair treatment of individuals, it is not advisable. Evaluation of the performance of individuals needs to take into account a **holistic picture** of the activities that each individual has done and the resources s/he has at disposal; it should also have a forward-looking component.

Each system has to create procedures for this kind of review, but a quasi-automatic use of biblio- or other metrics is **not** the solution. The evaluation should be based on a **qualitative judgement** of their portfolio and research activities by means of **peer review**, involving (more than one) experts in the specific field. The criteria for the assessment should go **beyond** the production of scientific outputs (quantity and/or quality) and also include involvement in knowledge transfer activities - in the research community or in the sphere of education, for the benefit of industry and/or society.

Especially in relation to the bibliometric indicators, the use of these metrics at the individual level can have ill-fated impacts on individual researchers and their careers. For decades, bibliometricians have warned against the use of bibliometric indicators for the evaluation of individual scientists. There are many challenges in bibliometric analysis as the previous sections elaborate, so various error factors should be expected (and are to a degree unavoidable). These error factors tend to cancel each other out at higher levels of aggregation, the more so the larger the entity that is under study. Research groups of 10 researchers are a minimum to reach any meaningful analysis. Reflecting our negative assessment of the journal impact factor (JIF) indicators in Section 4.2.4, above, we emphasise that JIF indicators and the h-index should **not** be used.

As a conclusion, we recommend the assessment of individual researchers to be based on a qualitative judgement of their portfolio and research activities by means of peer review, involving more than one expert in the specific field. It should take a holistic view on the research activity and go beyond the production of scientific outputs or impacts. JIF indicators and the h-index should not be used.

5 AN INTEGRATED PERFORMANCE-BASED RESEARCH FUNDING SYSTEM

In this conclusive chapter we focus on **how a revised performance-based research funding system in Bulgaria could look like and function**, taking account of our findings and recommendations presented in the preceding chapters.

Our starting point is the **two types of evaluation exercises** that the 2017 National Strategy envisages for the future, i.e. a 'periodic attestation' and an 'independent international evaluation' (see Section 2.3.2, above). The two evaluation exercises have different **purposes:**

- The 'periodic attestation', based on metrics (like the current methodology) will guide the allocation of the institutional funding of research. It is unclear from the description in the strategy as to whether the outcomes will govern all or only part of the institutional funding for research. It will be 'summative', i.e. judging past performance
- The 'international evaluation', based on international expert panels (peer review), will have a 'formative' function, i.e. it will advise on future strategies (at national and institutional levels) and will provide recommendations to improve the evaluation methodology and the attestation process for the institutions

In our opinion, it would be beneficial to integrate these two separate evaluation exercises and develop an **integrated evaluation system** where the two evaluation exercises would build upon and complement each other and would both be an integral part of the performance-based research funding system.

There are three possible scenarios for the function and focus of the two evaluation exercises in the context of an evaluation system (Table 16, below)

- Scenario 1 reflects the set-up suggested in the 2017 National Strategy. The metrics-based periodic attestation would function as the evaluation defining the performance- driven part of the institutional funding of research for all (eligible) institutions; the international panel evaluation would only provide guidance for improvement – both to the Ministry and the research institutions
- Scenario 2 sets out an integrated evaluation and funding system. The 'main' evaluation would be the international panel evaluation, setting the base line for the PRFS-driven part of the institutional funding for research (and eventually also defining the eligible institutions). For this purpose, it would take a comprehensive view on the value and relevance of research and the research activities. It would also have the envisaged 'formative' function and provide recommendations to the university/institution management and to the Ministry and national policy-makers for the improvement in the research policy and evaluation methodology.

  The periodic attestation would have a monitoring function only, with no or limited influence on the funding distributions (triggering funding fluctuations to a maximum of 10%). The main purpose of the periodic assessment would be to inform the university/institute's management about progress in achieving their targets/strategy, in preparation for the 'main' evaluation

- Scenario 3 attributes a full PRFS function to both exercises. While the panel evaluation would govern the distribution of the PRFS-driven part of the institutional funding for research, the periodic attestation would govern the distribution of a separate research funding budget line, for example as a 'bonus' or 'incentive' to reward research excellence.

Table 16: Scenarios for an integrated research evaluation system

<table>
<tr><th></th><th>Periodic attestation
Metrics-based</th><th>International evaluation
Panel evaluation</th></tr>
<tr><td>Scenario 1: Metrics-based PRFS</td><td>Governs the research funding for all (eligible) research institutions</td><td>No influence on funding</td></tr>
<tr><td>Scenario 2: Integrated PRFS</td><td>Monitors progress
No or however limited influence on research funding</td><td rowspan="2">Full evaluation
Sets the basis for the research funding of all (eligible) research organisations</td></tr>
<tr><td>Scenario 3: Double PRFS</td><td>Governs a separate budget line for research funding, as a bonus or incentive</td></tr>
</table>

Ideally, a decision on the matter should be taken *before either of the two evaluation exercises is launched*, including a mapping out of their functions and objectives, which will guide their design. International experience shows that once a performance-based funding system is implemented, it is politically difficult to make more than incremental changes to its design.

The sections below are intended to **support the decision-making** on these scenarios. We cover the key parameters for the design of a PRFS, taking on board the recommendations formulated in the preceding chapters and considering the consequences of the choices to be made for the three scenarios.

We start with the key design elements of any evaluation, i.e. the model for the evaluations and their scope and periodicity (Section 5.1). The purpose of the evaluations and the related choice of indicators and assessment criteria is the topic of Section 5.2.

We summarise our considerations and make recommendations in Section 5.3.

5.1 Model, scope and periodicity of the future PRFS in Bulgaria

Key parameters for the design of a PRFS are the model used for the assessment, the scope of research activity included (research, innovation, societal relevance), the type of indicators, the assessment criteria, the granularity of the evaluation, and its periodicity. Many of these elements are interlinked. The overarching model chosen for the assessment (i.e. peer review, bibliometrics or a combination of both), especially affects the granularity and the periodicity of the PRFS. It also directly influences the costs.

Below, we first give an overview of the main differences between the evaluation models and then cover the choices related to granularity and periodicity and the consequences for the three scenarios.

5.1.1 The model for the evaluation

The 2017 National Strategy already defined the model to be used for the two evaluation exercises, as mentioned above. The 2016 Pilot Evaluation Committee, however, considered: "The current assessment system will have to be changed in the course of time, turning to an assessment system that is similar to the assessment system AERES (France) or REF (England/UK)". Both of these assessment systems are peer review-based.

There is a strong variation in the use of these evaluation models, determined by the specific policy needs in the national R&D context as well as the background of the R&D governance system they are part of.

- In Austria and the Netherlands, research assessment has no explicit link to institutional funding. In both countries, the key focus of the evaluations is on informing institutional R&D management
- Norway, Finland and Belgium/the Flanders only use metrics-based PRFS, in the three countries complemented by other evaluations that are based on informed peer review, providing the 'formative' information required. It should also be noted that the PRFS drives only a small part of the institutional funding
- In 2003 and 2011, Italy ran an evaluation exercise similar to the UK in terms of size and depth. Both Australia and Italy make a selective use of bibliometrics versus the panel model, i.e. bibliometrics for the hard sciences and peer review for the others
- The UK and New Zealand are similar in that they both firmly use peer review-based evaluation methodologies. A distinction is that the UK REF focuses on research excellence, the New Zealand RAE on research quality

The choice between metrics and peer review is contentious; both have their strengths and weaknesses.

Notions such as research quality and impact are best *judged* by experts rather than *assessed* by metrics. This relates in particular to the capacity of **expert panels** adequately to assess the performance of actors in the different fields (and sub-fields) of science. Peers possess the required specific knowledge and understanding to take into account the specifics of the disciplinary cultures, ranging from different publication profiles to the needs for research infrastructure, as well as the roles of the different actors in the R&D system for the field, and can position it in an (international) quality framework. PRFS that use peer review are more comprehensive and appear to have greater credibility and buy-in (NZ Ministry of Education, 2012).

Peer review also has its inherent problems: it is costly and time consuming, prone to bias, leaves no audit trail and can even be open to abuse. However, except for the costs, many of these weaknesses can be neutralised by means of procedural guarantees, ensuring quality management in the evaluation process.

The weaknesses of the panel method are exactly the kinds of problems that (**biblio)metric systems** address. However, there may be problems with the bibliometric data coverage in certain fields of research, and policymakers generally fail to adopt many of the more sophisticated indicators the bibliometricians can provide, often leading to the use of very basic bibliometrics. Another weakness of metrics-based evaluations is in the unique reliance on quantitative data and therefore the critical importance of the data's quality.

An increasing number of systems combine the two approaches. The **'informed peer review'** model uses metrics, such as bibliometrics or indicators of innovation outputs, to inform the evaluation panels - to varying degrees and at the peers' discretion. The evaluation method hereby exploits the ability of indicators to represent large sets of data in a simplified overview while exploiting the ability of peers to make more qualified judgments about excellence, coherence and other qualitative aspects that cannot be achieved through metrics alone.

5.1.2 Scope and periodicity of the evaluation

A primary condition for the design of PRFS, especially in the current financial crisis and restrictions on public administration budgets, is that evaluation **should not cost too much money** as compared with the overall amount of research funding being distributed. The rule of thumb is that the overall cost should not exceed **1-2% of the research funding distributed**.

The cost-efficiency of a PRFS is directly linked to the decisions taken in relation to the *granularity of the assessment* and the *periodicity* of the evaluation. Some major adjustments are required to the current PRFS from that perspective.

Granularity of the assessment relates to the extent to which the evaluation (and funding) system includes all research-performing institutions and researchers in the country. Minimal-scale levels for the units of analysis need to be defined, taking into account the structure of the research system. For peer review-based evaluations, units of analysis should be defined at the level where the research strategy of the research unit is defined. In HEIs, this is typically the departmental level (see Section 4.3.1).

There is also a need for the definition of a volume measure to relate the quality measurement to the different sizes of units of analysis assessed. We advised in Section 4.3.2 that this should be defined in the form of FTE researchers.

The **periodicity** of an evaluation is linked to the model used. Metrics-based evaluations are less resource- and time-intensive than peer review-based ones as they can easily build upon routine data collections. They can therefore provide a more up-to-date picture of performance and are more easily used for the assessment of progress. They are very often run on an annual basis.

The major difficulty in metrics-based evaluations is to define the appropriate indicators to ensure fairness and robustness of the system and to find the appropriate balance between practicality and perfection, limiting the volume of information required from the research institutions.

A significant limitation of the metrics-based model for PRFS is also that it is hard in a homogenous metrics-based system to take account of the differences in roles and missions in research and society of different research-performing organisations. This consideration is especially of relevance in the context of the restructuring of the R&I system that we propose in Section 0, above, creating a system structured around scientific research institutions, entrepreneurial universities, RTOs and government labs. Separate PRFS will be needed in order to take these missions sufficiently into account in the evaluation process and address their specific failures (eg through different weighting systems for the assessment criteria)

Peer review-based evaluations, instead, are run at longer (regular) intervals, e.g. every 5 years, because of the higher costs of these exercises but also to allow for the operational set-up of the evaluation. This includes the selection and nomination of the international peers and panels, but also the refinement of the methodology (based on lessons learnt from the previous exercise); the development of protocols for the panels, the participating research institutions and the staff of the entity in charge of the exercise; and the development of the IT system for the collection and analysis of the data.

A PRFS at longer regular intervals ensures stability for the PROs' budgets, thus allowing for continuity for the research activities.

An important condition for the use of the peer review-based model as the main evaluation is the capacity and expertise of the entity responsible for the implementation of the evaluation exercise. A national peer review exercise is a complex and labour-intensive exercise. This requires professional management and a professional support organisation. The management must prepare and coordinate the whole review and is also responsible for the communication to the research organisations. It is also important that the panels and the management are supported by staff, e.g. taking notes, preparing meetings, arranging facilities, etc. This also includes support tools like online systems and a database for statistics, publications and other outputs.

5.1.3 Consequences for the scenarios

Table 17, below, illustrates the effects of the principles enumerated in this Section on the scenarios defined above.

It shows that scenarios 1 and 3 have significant disadvantages in terms of flexibility (i.e. taking missions into account), a capacity for monitoring and rewarding progress or creating a minimum of research funding stability, and the risks they present in terms of fairness and robustness of the evaluation methodology and fragmentation of the limited government budget for research.

An **integrated evaluation system** (Scenario 2) therefore seems the best option, i.e. an international panel evaluation, based upon informed peer review, which would have the function of a main evaluation exercise, governing the performance-based part of the institutional funding for a period of 5 years, with minor annual adjustments to reward progress, based on a metrics-based monitoring system.

Table 17: Pros and cons of the PRFS scenarios

Scenario 1 *Metrics-based PRFS*	Scenario 2 *Integrated PRFS*	Scenario 3 *Double PRFS*
Key parameters		
• Main evaluation annually - metrics-based	• Main evaluation every 5 years – peer review • Annual monitoring of progress – metrics-based	• Main evaluation every 5 years - peer review • Targeted annual evaluation – metrics-based
Pros		
• Immediately rewards research performance • In line with the 2017 National Strategy • Very cost-efficient	• Allows for rewarding progress • Enables stability in funding • Can take missions into account	• Enables stability in funding • Can take missions into account • Can specifically reward excellence
Cons		
• Sets high quality requirements for the evaluation methodology to ensure fairness and robustness of the results • Does not ensure stability in research funding • Cannot take missions into account so different PRFS are needed for different types of organisation	• Requires long-term planning at government level • Requires capacity in the Ministry or elsewhere to run a high-quality panel evaluation process • Less cost-efficient	• Does not allow for monitoring and annual adjustments rewarding progress • Risks fragmenting the limited government budget for research • Requires long-term planning at government level • Requires capacity in the Ministry or elsewhere to run a quality panel evaluation • Less cost-efficient

5.2 *Purpose of the evaluation and the choice of indicators and assessment criteria*

In this section, we first set out a series of concepts that underlie and characterise the purpose of evaluations and the choice of indicators and propose a list of potentially relevant indicators for research performance assessment in the Bulgarian PRFS. We also summarise our key findings and considerations from the analyses in the preceding chapters. We cover a key aspect of the link from indicators to policy, i.e. the weights attributed to assessment criteria. In the next section we describe the potential benefits of the use of self-assessments. We reflect on the consequences of these elements of a PRFS design for the three scenarios in Section 5.2.4.

5.2.1 Purpose of the evaluation and the choice of indicators

Knowledge is the major outcome of science and research and should be the focus of a research funding system. It also constitutes its major value – for research, industry and society alike. An evaluation system that intends to understand research performance in its broader sense, i.e. not limited to the number and scientific quality of research outputs, must also assess the **extent of knowledge exchange**.

- Different knowledge exchange mechanisms transfer different types of knowledge.
- Publications and patents transfer codified (written) knowledge
- More interactive mechanisms, such as contract and collaborative R&D, transfer both codified and tacit knowledge (know-how, skills).

Knowledge exchange mechanisms can be understood as **pathways to impact**, i.e. those aspects that are critical for the creation of impacts – in the form of increased knowledge and potential use of the research outputs for advancements in research or innovation. They are typically assessed through the use of two categories of indicators: process indicators and systemic indicators (see also Section 4.1, above).

The particular actors concerned depend on the institutional and network failures in the research system. In Bulgaria, these are the continuing research-education divide, the limited research collaboration among the HEIs, between the HEIs and the research institutes, between science and industry, and between Bulgarian and international researchers (see Section 2.2, above).

Categories of policy objectives can be defined in terms of: *capacity*-building; enhancing the *quality or excellence* of research; *relevance* of the research for science, innovation and society; and objectives aimed at creating *systemic effects* to enhance the quality and/or sustainability of the research system.

The 2017 National Strategy defines policy objectives in all those areas, adding the dimension of *internationalisation* of research (see Section 2.3.2, above). While the current evaluation methodology emphasises research capacity and quality, with indicators strongly oriented towards the sphere of research, the strategy considers that research should also have societal and cultural relevance and anticipates the inclusion of indicators geared towards fostering applied research in a future revision of the evaluation methodology.

In Table 18, below, we map the **indicators** that in our opinion could be used in a Bulgarian PRFS to address the main challenges and failures in the system, against the relevant categories of policy objectives.

Compared to the current PRFS, our mapping devotes more attention to the *'relevance'* objectives and especially to the objective of ensuring *quality and sustainability of the R&I system*, emphasising therefore the use of systemic indicators (amongst which co-publications). We omitted the use of 'esteem' indicators (awards, memberships of journal boards etc.) as we consider these to be of limited importance. Bearing in mind the need to distinguish between the national and international dimensions of research, a distinction is made concerning this dimension in all relevant indicators.

It should be noted that we mapped out **all potentially relevant** indicators. By no means does this imply that they should all be used. The ambition should be to set up the simplest possible indicator mix where the indicators complement each other while reflecting the policy objectives and priorities.

Table 18: Policy objectives and the potential metrics in the Bulgarian PRFS

Indicators in international practice	Capacity	Quality / excellence	Relevance	Internationalisation	Systemic effects
OUTPUT INDICATORS					
Scholarly outputs - articles, monographs/ books	X				
Scholarly outputs - proceedings int'l conferences	X			X	
Non-scholarly outputs	X		X		X
Innovation-related outputs (IPR) (patents, design, rights, etc.)	X		X		X
PROCESS INDICATORS					
PhDs awarded	X		X		X
EXTERNAL FUNDING INDICATORS					
Competitive funding / national (including Structural Funds)		X	X		
Competitive funding / international		X		X	
Contract research funding (industry & public administration)		X	X		X

Indicators in international practice	Capacity	Quality / excellence	Relevance	Internation alisation	Systemic effects
SYSTEMIC INDICATORS					
Co-publications / international		X		X	X
Co-publications national / HEI-institutes	X				X
Co-publications national / research-industry	X				X
Joint research projects HEI - Institutes	X				X
Joint research projects HEI - HEI	X				X
Joint research projects research-industry	X		X		X
International mobility (out/in-going) (invited lectures)				X	X
OUTCOME/IMPACT INDICATORS					
Citations (field-normalised)		X			
Spin-offs, volume of income licences etc.			X		X

The key criterion for the selection of the indicators should be the extent to which the policy objectives are adequately addressed combined with the need for the system to be **fair and balanced**. Listed below are the most relevant considerations and principles that we highlighted in the preceding chapter. Key from this perspective is also the definition of assessment criteria to group the different indicators (see Section 5.2.2, below)

- In PRFS, the <u>focus of indicators and their form</u> do not only have the function of assessing and awarding the 'good', but also of creating <u>incentives</u>. The selection of the indicators should be based on a careful consideration of the incentives created and their potential positive and negative effects. For example, in the metrics-based evaluation in scenario 3 where the key objective is to reward excellence, one could consider using the size-independent variation for a limited number of indicators if the intent is to increase concentration of the funding on the most excellent performers
- A balanced use of the research output indicators is key to guaranteeing fairness in the evaluation and alignment with the needs in the system as well as to avoid strategic behaviour (i.e. gaming) and potentially negative effects of the PRFS. Especially important is the balance between fostering the creation of <u>capacity</u> for research and rewarding <u>'excellence'</u> in research

- It is also important to maintain a balance between rewarding research conducted internationally or gaining international visibility and rewarding research responding more directly to national needs. Excessive focus on internationally-relevant research risks creating a 'horizontal fragmentation' in the national R&I system, i.e. the concentration of funding on 'islands of excellence' in research that locally may not be necessarily relevant
- Fairness of the research evaluation system should be sought through appropriate attention to the specifics of the scientific fields, the missions in society of the different institutions involved, and the characteristics of the different groups of actors involved, e.g. age groups, regional actors etc. The detail of the field categorisation is a key facilitator, as are the balanced selection of indicators and their weighting, and the use of an appropriate reference period for the bibliometric indicators
- Bibliometric indicators should be of an advanced nature, while the use of Journal Impact Factors and the H-index is inappropriate in the context of research evaluations

Recognising the **current urgent need to have at least some quality indication** for the allocation of research funding based on the current metrics-based system, our proposal is to include the following limited number of indicators for the calculation of the final scores, each with an equal weight:

- The three scholarly output indicators (articles, monographs/books, proceedings)
- The non-scholarly outputs (precisely defined and delimited)
- The innovation-related indicators
- The number of PhDs awarded (eventually using a size-independent indicator) and
- The three joint research project indicators OR the three co-publication indicators (all fractionised)

Our selection is based upon the key principle that a small number of indicators should be included, out of which *only a few* (one to three) are bibliometric. We prioritised the enhancement of research capacity and the creation of systemic effects in our selection, and took into account both the limits to the data currently available and the fact that time is needed for the development of advanced bibliometric indicators.

5.2.2 Assessment criteria and their weighting

Fairness, transparency, and simplicity are overarching principles for a PRFS design. While fairness and transparency are crucial characteristics of any PRFS, **simplicity** can be hard to achieve.

- In those cases where the performance assessment in the PRFS is the only evaluation conducted at the national level, the PRFS tend to be more complex, drawing on a relatively broad range of indicators to satisfy a range of policy needs, strategic priorities and ambitions. It is the **combination** of the **indicators** selected and the **weights** defined for the assessment criteria that allow complex systems to conduct an all-round assessment while still putting priority on the most urgent failures in the system to address

- In countries where evaluations in the context of PRFS are combined or complemented with other evaluations at the national level that do not drive funding and have a different function, the evaluations in the PRFS can rely on **simple** indicators to address the specific policy objectives. In these cases, weights for the funding formula can be defined at the level of specific indicators, enhancing the steering effects of the PRFS. The PRFS for universities in Finland is an example

Institutional funding for universities in Finland

In Finland, institutional funding for teaching and research is determined by a comprehensive development plan established by the government every four years. In this model, performance contracts and the funding formula with performance indicators for teaching and research (i.e. the PRFS) act as complementary tools. At the beginning of every three-year term, negotiations are conducted and performance agreements signed between the universities and the Ministry establishing operational and qualitative targets, as well as the resources required.

Monitoring and evaluation indicators are defined, reflecting the most urgent needs for policy intervention.

In 2015, the institutional funding was calculated based on a set of 17 indicators covering three areas: education, research and strategies/national tasks. Each of the indicators contributed to one or more of three policy objectives: efficiency, quality and internationalisation. Table 19 shows the indicators selected for the research component.

Table 19: Institutional funding system for universities in Finland (2015)

Efficiency		Quality		Internationalisation	
Completed PhD degrees	9%	Scientific publications	13%	Competitive research funding / international	3%
		Competitive Research Funding / national	6%	Completed PhD degrees of foreigners	1%
				Foreign academic staff	2%

In peer review-based evaluations, weight systems related to the policy objectives are defined at the level of assessment criteria. Internationally, the assessment criteria against which the panel members are expected to formulate a final judgement are broadly similar (Table 20).

Some small differences emerge: the 'pure' peer review-based systems shown (SEP and REF) also consider the **institutional environment** and **self-assessments** by the universities. The use of self-assessments is covered in the next section.

Table 20: Assessment criteria in national evaluation frameworks involving peer review

	Australia – ERA 2015	Netherlands – SEP 2015	Italy – VQR 2011	UK REF 2014
Outputs	Volume and activity; publishing profile; peer review; citations; research income	Research quality	Originality & innovation	Originality, significance and rigour
Relevance/ impact	Applied measures (IPR and research commercialisation)	Relevance to society	Relevance for the advancement of knowledge and social benefits	Reach and significance
			Technology transfer activities and (potential) socio-economic fallouts	
Environment		Viability		Vitality and sustainability
Esteem	Esteem measures (at eligible researcher level)		Internationalisation and/or international standing	

Source: Mahieu & Arnold, 2015

5.2.3 The use of self-assessments

The most basic difference between metrics-led evaluations and peer reviews is the capacity of the peer review-based evaluation to take account of qualitative information. In many cases, the assessment is carried out in two stages with a self-assessment followed by an external assessment.

It is important to make a difference between self-reporting and self-assessment.

- **Self-reporting** refers to the submission of 'hard' data such as numbers of people, lists of publications, numbers of PhD students etc. by the institutions involved in the evaluation. The rule of thumb, however, is that as much as possible, data should be collected centrally as much as possible, using external data sources or reliable national information systems (including a national RIS if relevant) as data are often unreliable (see Section 0, above). In the context of peer review-based evaluations, the institutions are often asked to provide factual information on the 'research environment', for example a breakdown of the resources for research in the unit of analysis
- **Self-assessment** is one of the components of a two-stage assessment whereby qualitative information is provided for the peer reviewers to take into account during their assessment. It typically also includes prospective elements, i.e. intentions for the future. This information is of critical importance in peer review-based evaluations, especially in the absence of on-site visits

The focus of the self-assessment depends on the objectives of the evaluation and to an extent, on the level of sophistication of the evaluation methodology and the maturity of the evaluation culture in the country.

In most cases, self-assessments include a description of the research activities in the unit of analysis and the key achievements; a description of the research strategy, in the past and for the future; information on the approach to human resource management and PhD training; a description of the infrastructure and facilities; a reflection of the value and relevance of the research activities; and a reflection on the competitive positioning in the national and international context.

In the UK, where there is a long-standing tradition of institutional and national evaluations, the self-assessment in the REF also included narratives providing examples of impacts achieved in the socio-economic sphere, an approach that is unique to the REF. In other cases, the self-assessment concludes with a SWOT (strengths, weaknesses, opportunities and threats) analysis, including a perspective for the future.

The key concept is that the self-assessment is performed by the researchers and their management who are effectively involved in the units of analysis. It therefore also constitutes an opportunity for the researchers **collectively** to reflect on the value and relevance of their research, on their achievements and their research strategy for the future.

Such self-assessment reports would be structured according to a **well-defined protocol** containing definitions, in order to minimise differences of interpretation about the facts to be collected. International experience shows that researchers and their managers often need to be advised on how to deal with providing such information in the context of evaluation. The extent of 'evaluation culture' among different groups of researchers differs across both countries and subjects. It is easy to disadvantage groups with little evaluation experience.

5.2.4 Consequences for the scenarios

In the case of **scenario 1 (metrics-based PRFS)**, the annual monitoring system would need to be a comprehensive system addressing all policy objectives and therefore most of the indicators listed. This would turn the metrics-based system into a highly complex assessment exercise, requiring a large number of data points to be collected by the research-performing actors involved.

In the case of **scenario 2 (integrated PRFS)** and **scenario 3 (double PRFS)**, the comprehensive evaluation would need to be done only once every 5 years, by means of peer review. The international evaluation will be an all-round assessment, informed by the monitoring results, a self-assessment, and eventually some additional metric indicators.

It would allow for including the quality of the institutional research environment among the criteria driving the performance-based component of the institutional funding. It is important to support the creation of good institutional practice in the recruitment and career management of researchers, to encourage the institutions to improve their management practices and to remove barriers to acquiring external funding, since these can prevent the behaviour patterns PRFS is attempting to promote.

The periodic assessment would then be able to focus on indicators addressing the most urgent failures in scenario 2 (e.g. research capacity and the quality of the research system), or exclusively on research quality/excellence in scenario 3.

Also in this case, we prefer scenario 2.

5.3 Summary and recommendations

The 2017 National Strategy envisages the conduct of two types of evaluation exercises for the future, i.e. a metrics-based 'periodic attestation' and a peer review-based 'independent international evaluation'. Three scenarios can be envisaged for this integrated evaluation system, depending on 1) which of the two evaluation exercises will function as the 'main' evaluation and govern the performance-based component of the institutional funding system, and 2) the function of the other evaluation exercise.

We advise the Bulgarian authorities to set these two evaluation exercises within an overall framework, creating an *integrated evaluation system* where the 'main' evaluation would be peer review-based. It would allow for the creation of complementarities between the metrics- and the peer review-based exercises, whereby the strengths of each of these evaluation models can be exploited, and their weaknesses avoided.

We propose an international panel evaluation, based on an informed peer review, to function as the main evaluation exercise and govern the performance-based part of the institutional funding for a period of 5 years - with minor annual adjustments to reward progress, based on a metrics-based monitoring system. This approach would allow for including the quality of the institutional research environment among the criteria driving the performance-based component of the institutional funding. It would also allow for sharpening the focus of the metrics-based 'periodic assessment on the most urgent failures in the system that need to be addressed.

Knowledge is the major outcome of science and research and should be the focus of a research funding system. It also constitutes its major value – for research, industry and society alike. Knowledge exchange mechanisms can be understood as *pathways to impact*, i.e. those aspects that are critical for the creation of impacts – in the form of increased knowledge and potential use of the research outputs for advancements in research or innovation. Based upon these considerations, we mapped the indicators that in our opinion could be used in a Bulgarian PRFS to address the main challenges and failures in the system, against the relevant categories of policy objectives. The selection of these indicators should be based upon the policy objectives for the evaluation and the priorities set. This is, however, a policy decision that goes beyond the mandate of this study.

Recognising the **current urgent need to have at least some quality indication** for the allocation of research funding based on the current metrics-based system, we advise the inclusion of a limited number of indicators for the calculation of the final scores, each with an equal weight, out of which *only a few* (one to three) are bibliometric. **Prioritising the enhancement of research capacity and the creation of systemic effects, we recommend the inclusion of the following indicators**:

- Three scholarly output indicators (articles, monographs/books, proceedings)
- One non-scholarly outputs indicator (precisely defined and delimited)
- Two innovation-related indicators (patents and other IPR)
- One PhDs awarded indicator (eventually using a size-independent indicator)
- Three joint research project indicators OR three co-publication indicators (all double-counted)

Self-assessment will be an important component of the international panel evaluation. It should involve transparent questions which have been clearly explained by the PRFS managers. It can be expected that there will be significant differences in 'evaluation culture' among the research institutions in the Bulgarian system, as well as in the sufficient knowledge of English. Groups with little evaluation experience and/or knowledge of English therefore risk being disadvantaged. **We urge the Bulgarian authorities to move gradually towards full English reporting of research outputs. In our view, a scheme of systematic *self-assessment* should be introduced as a pilot exercise and the first step in the preparation for international external peer assessments.**

An important condition for the use of the peer review-based model as the main evaluation is the capacity and expertise of the entity responsible for the implementation of the evaluation exercise. A national peer review exercise is complex and labour-intensive. This entity should also be in charge of designing and updating the evaluation methodology, including the metrics-based assessments. Taking the complexity of these exercises into account, **we recommend putting a special unit, in charge of the evaluations, created for the purpose, which has the necessary capacity and resources and make use of the country's best of expertise. It should be supported by external expertise in indicator development and analysis, especially in the field of bibliometrics.**

6 ANNEX A: BIBLIOGRAPHY

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To support countries in reforming their research and innovation systems, the Directorate-General for Research & Innovation (DG RTD) of the European Commission set up a Policy Support Facility (PSF) under the European Framework Programme for Research & Innovation 'Horizon 2020'. It aims to support Member States and associated countries in improving their national science, technology and innovation systems.

The Bulgarian government requested specific support from the PSF, as a basis for the finalisation of the national performance-based research funding system (PRFS).

The PSF panel of four independent experts worked from January to December 2017, including a mission to Sofia to consult stakeholders and discuss potential recommendations. A preliminary version of this final report was presented to the Bulgarian government in Sofia during October 2017. The panel's recommendations focus on

- The need to implement a structural reform of the R&I system as a precondition for any PRFS to be effective
- How to refine the current PRFS design to ensure the introduction of a fair, transparent, simple and low-cost PRFS
- The options for designing an integrated evaluation and research funding framework

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