**AGRICULTURAL UNIVERSITY PLOVDIV**

**FACULTY OF ECONOMICS**

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# IMPACT OF CENTRES OF EXCELLENCE ON THE DEVELOPMENT OF THE BIOECONOMY IN EUROPE

AUTHOR'S ABSTRACT

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**CONTENT**

# INTRODUCTION

The bioeconomy has emerged as a key conceptual and practical approach to sustainable development in response to increasing pressure on natural resources, climate change, demographic challenges, and the need to transform traditional economic models. It represents an integrated system based on the sustainable use of renewable biological resources, innovation, and circular production and consumption models, linking agriculture and forestry, biotechnology, bioenergy, and bio-based industries with scientific research and technological development.

The European Union plays a leading role in the development and institutionalisation of the bioeconomy through strategic policies, financial instruments, and initiatives aimed at fostering research and innovation. The EU Bioeconomy Strategy of 2018 and its 2025 update, together with the European Green Deal and the United Nations Sustainable Development Goals (SDGs), provide the framework for the transition towards a more sustainable and competitive economy. In this context, Centres of Excellence (CoEs) have emerged as key institutional structures that bridge scientific research with practical applications, industry, and public policy.

***The main objective of this study*** is to analyse the role of Centres of Excellence in the development of the bioeconomy in Europe by assessing their impact on the innovation ecosystem and identifying strategic directions for future development, with a particular focus on the Centre of Plant Systems Biology and Biotechnology (CPSBB) in Bulgaria.

***The object of the research*** is the Centres of Excellence in Europe as an integral part of the European research and innovation system.

***The subject of the research*** is the role of Centres of Excellence in fostering the development of the bioeconomy, including their organisational models, funding mechanisms, interactions with other institutions, and socio-economic impacts, with particular emphasis on the case of the Centre of Plant Systems Biology and Biotechnology (CPSBB) in Bulgaria.

To achieve the research objective, the following research tasks have been formulated:

1. To clarify the theoretical and conceptual foundations of the bioeconomy, including its origin, development, and main directions.
2. To analyse the European and international strategic frameworks related to the bioeconomy, including the EU Bioeconomy Strategy, the European Green Deal, and the Sustainable Development Goals.
3. To examine the institutional and innovation infrastructure supporting the bioeconomy at the European, national, and regional levels.

4. To define and classify Centres of Excellence and analyse European policies for their establishment and funding.

5. To investigate the organisational models, governance structures, and partnerships of leading Centres of Excellence in Europe.

6. To assess the socio-economic impact of Centres of Excellence on regional and national development.

7. To conduct an in-depth analysis of the Centre of Plant Systems Biology and Biotechnology (CPSBB) in Bulgaria, focusing on its mission, organisational structure, scientific achievements, funding, and international partnerships.

8. To evaluate the contribution of CPSBB to the development of the regional and national bioeconomy.

9. To formulate recommendations for the optimisation and strategic development of Centres of Excellence in line with European priorities.

The methodological framework of this research is based on the integration of qualitative and quantitative research methods in order to achieve a comprehensive understanding of the role of Centres of Excellence in the development of the bioeconomy. This approach enables the simultaneous analysis of the institutional, organisational, and strategic characteristics of the selected centres, as well as the empirical assessment of the perceptions and experiences of key stakeholders. By combining case study analysis, documentary analysis, semi-structured interviews, and questionnaire surveys, the research ensures methodological coherence and enhances the reliability and analytical validity of the findings.

From a conceptual perspective, the methodological framework integrates three interrelated approaches: innovation systems theory and the Triple Helix model, the understanding of the bioeconomy as a transformative framework for sustainable development, and approaches for assessing organisational and institutional impacts. This allows Centres of Excellence to be examined not merely as research organisations but as strategic intermediaries connecting fundamental science, technological innovation, industry, and public policy. Consequently, the selected methodology provides a robust basis for analysing scientific productivity and governance models, while also evaluating the contribution of Centres of Excellence to knowledge transfer, regional development, and the transition towards a sustainable bioeconomy.

# CHAPTER ONE: THEORETICAL AND CONCEPTUAL FOUNDATIONS OF THE BIOECONOMY AND THE ROLE OF CENTRES OF EXCELLENCE

The first chapter examines the theoretical foundations and evolution of the bioeconomy concept by analysing the principal scientific approaches and international interpretations of the term. The development of the bioeconomy is traced from its early theoretical origins to contemporary European and global policies aimed at the sustainable management of biological resources and the transition towards a low-carbon economy.

The chapter explores the main sectors, dimensions, and technological drivers of the bioeconomy, as well as its interconnections with the circular economy, the green economy, and sustainable development. Particular attention is devoted to the strategic policy framework of the European Union, including the EU Bioeconomy Strategies of 2018 and 2025, the European Green Deal, and the United Nations Sustainable Development Goals.

Furthermore, the institutional and innovation infrastructure supporting the bioeconomy at the European, national, and regional levels is analysed, with particular emphasis on the coordination mechanisms between research organisations, industry, and public institutions.

Special consideration is given to the role of Centres of Excellence (CoEs) as a key component of the European innovation ecosystem. Their main characteristics, operational models, and contributions to scientific research, knowledge transfer, and the implementation of innovations in the bioeconomy are examined.

The findings demonstrate that the bioeconomy constitutes a complex system based on the sustainable utilisation of biological resources, scientific advances, and technological innovation. The analysis confirms that Centres of Excellence play a significant role in the development of the bioeconomy by generating scientific knowledge, fostering innovation ecosystems, and creating sustainable partnerships among academia, industry, and the public sector. These theoretical insights provide the conceptual foundation for the subsequent analyses presented in the dissertation.

The study is based on a methodological framework that combines qualitative and quantitative research methods to ensure a comprehensive and in-depth understanding of the role of Centres of Excellence (CoEs) in the development of the bioeconomy. The selected research design follows the mixed-methods approach, in which qualitative and quantitative techniques complement one another and enable data triangulation (Creswell & Plano Clark, 2018).

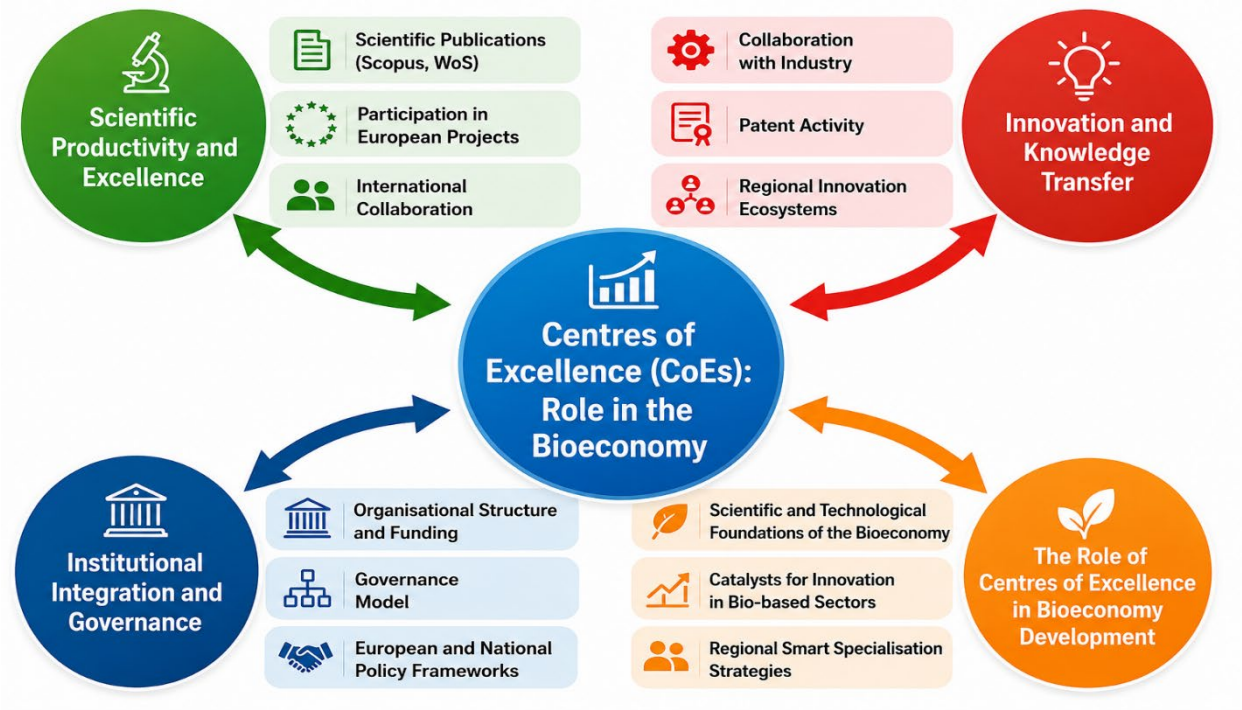
The principal research methods employed in the dissertation include:

1. A case study analysis

2. Documentary analysis of strategic, policy, and institutional documents;
3. Semi-structured interviews with key stakeholders;
4. A questionnaire survey among researchers, partners, and relevant stakeholders.

The combination of these methods facilitates both an in-depth understanding of the institutional and innovation dynamics of Centres of Excellence and an empirical assessment of stakeholder perceptions, impacts, and development challenges (Figure 1).

**Figure 1. Integrated role of Centres of Excellence in scientific productivity, innovation, and the bioeconomy**




*Source: Author's own research.*

The conceptual framework of the dissertation is built upon the integration of three interrelated theoretical perspectives:

*1. Innovation Systems and the Triple Helix Model*

The study adopts the concepts of national and regional innovation systems (Lundvall, 1992; Edquist, 2005) and the Triple Helix model of university–industry–government interactions (Etzkowitz & Leydesdorff, 2000). Within this framework, Centres of Excellence are regarded as key intermediaries in knowledge-intensive innovation ecosystems, connecting scientific research, technological development, and economic application.

*2. The Bioeconomy as a Transformative Framework*

The PhD thesis draws upon contemporary concepts of the bioeconomy as a strategy for sustainable development that integrates biological resources, technological innovation, and circular production models (European Commission, 2018; Bugge, Hansen & Klitkou, 2016). Within this perspective, Centres of Excellence are considered catalysts for scientific and technological progress in the bio-based sectors.

*3. Organisational and Institutional Impact Theory*

The assessment of the impact of Centres of Excellence is based on institutional theory and approaches to evaluating public research organisations (DiMaggio & Powell, 1983; Bozeman, 2000). This perspective facilitates the examination of how institutional structures, governance models, and funding mechanisms influence scientific productivity and the societal value generated by research centres.

These three theoretical perspectives constitute the analytical foundation of the dissertation and guide the selection of methods, indicators, and evaluation criteria.

The methodological design of the dissertation incorporates four complementary research methods: comparative case study analysis, documentary analysis, semi-structured interviews, and questionnaire surveys.

The comparative case study analysis focuses on four leading European Centres of Excellence in plant systems biology: Centre of Plant Systems Biology and Biotechnology (Bulgaria); John Innes Centre (United Kingdom); Max Planck Institute for Molecular Plant Physiology (Germany); VIB–Ghent University Centre for Plant Systems Biology (Belgium).

The case selection was based on purposive sampling, taking into account scientific specialisation, organisational models, and participation in European research programmes. The analysis is structured around four principal dimensions: scientific productivity, institutional governance, innovation and knowledge transfer, and contribution to the development of the bioeconomy.

Documentary analysis provides the informational basis for the study through a systematic review of European and national strategic documents, institutional materials of the selected centres, scientific databases, and reports produced by international organisations. This method enables the tracking of the evolution of European bioeconomy policies and the assessment of the role of Centres of Excellence within the research and innovation system.

The qualitative component of the research is complemented by semi-structured interviews conducted with representatives of academia, funding organisations, industry, and

bioeconomy experts. The interviews were based on a predefined thematic guide and analysed using thematic analysis, enabling the identification of the principal factors influencing the development and impact of Centres of Excellence.

The quantitative component of the research was implemented through a standardised questionnaire survey conducted between January - March 2026. The primary data collection instrument was an online questionnaire developed using Google Forms.

The questionnaire was structured into five thematic sections covering respondents' profiles, the strategic role of Centres of Excellence, their scientific and economic contributions, governance and sustainability, and the major challenges and future development prospects. Descriptive statistical methods, including frequency distributions, percentages, mean values, and graphical representations, were employed to analyse the collected data.

The combination of comparative case study analysis, documentary analysis, semi-structured interviews, and questionnaire surveys provides methodological triangulation and enhances the reliability of the findings. This integrated approach enables a comprehensive examination of the role of Centres of Excellence in the development of the bioeconomy and establishes a solid basis for scientifically grounded conclusions and practical recommendations.

Despite limitations related to purposive sampling, the use of descriptive statistics, and the dynamic nature of European policy developments, the applied methodological framework provides a reliable basis for analysing the scientific, innovation, and socio-economic impacts of Centres of Excellence on the development of the bioeconomy.

The empirical component of the dissertation aims to assess the role and impact of Centres of Excellence on the development of the bioeconomy in Europe, with particular emphasis on the Centre of Plant Systems Biology and Biotechnology (CPSBB). The methodological framework follows the adopted mixed-methods approach, integrating qualitative and quantitative analytical techniques to achieve a more comprehensive understanding of the research phenomenon and enhance the robustness of the findings.

For the purposes of the empirical study, a total of 100 questionnaires were distributed among Bulgarian and international organisations and experts engaged in the fields of the bioeconomy and research and innovation infrastructure.

The survey yielded:

- 42 valid responses from Bulgaria;
- 26 valid responses from international participants.

The total number of analysed questionnaires was 68, representing an overall response rate of 68%.

The achieved response rate can be considered satisfactory for an international online survey, particularly given the specialised nature of the target group, which comprises highly qualified experts and representatives of research and innovation organisations.

The questionnaire survey constitutes a key quantitative component of the present research and aims to collect systematic data on the perceptions, evaluations, and attitudes of various stakeholders regarding the role, impact, and future development prospects of the Centre of Plant Systems Biology and Biotechnology (CPSBB) within the context of the bioeconomy, scientific and technological advancement, and regional development. The survey method is widely employed in social and innovation research because it enables the collection of standardised data from a relatively large number of respondents and facilitates the quantitative summarisation of research findings (Bryman, 2012; Fowler, 2014).

The questionnaire survey in this dissertation primarily serves a descriptive purpose, with the main focus placed on the presentation and interpretation of descriptive statistics, including frequency distributions, percentages, mean values, and graphical visualisations. This approach is consistent with the research objective, which seeks to map stakeholder perceptions and identify major trends rather than to test causal relationships or hypotheses (Babbie, 2016).

The questionnaire was designed to achieve several interrelated objectives:

- To obtain structured information regarding the profile of the respondents and their relationship with CPSBB;
- To assess the perceived strategic role of CPSBB at both the national and European levels;
- To identify the perceived scientific, technological, and economic impact of the Centre;
- To collect opinions concerning the governance, funding, and long-term sustainability of CPSBB;
- To identify the main constraints and future priorities as perceived by relevant stakeholders.

These objectives are aligned with the conceptual framework of the study, which considers Centres of Excellence as key institutional actors within innovation systems and the bioeconomy (Etzkowitz & Leydesdorff, 2000; Bugge, Hansen & Klitkou, 2016).

The present research provides an in-depth analysis of the role and impact of Centres of Excellence in the field of plant systems biology and the bioeconomy through the integration of qualitative and quantitative research methods. Nevertheless, as with any empirical investigation, the study is subject to a number of methodological and conceptual limitations that should be taken into account when interpreting the findings.

Despite these limitations, the research offers a robust assessment of the role of Centres of Excellence in the development of the bioeconomy. The combination of complementary research methods, the critical approach to data interpretation, and the explicit recognition of methodological constraints enhance both the scientific value and the transparency of the study.

## CHAPTER TWO: CENTRES OF EXCELLENCE IN EUROPE AND THEIR ROLE IN THE INNOVATION SYSTEM

The second chapter is related to the theoretical and comparative analysis of Centres of Excellence (CoEs) as an instrument of European research, innovation, and bioeconomy policy. It examines their conceptual characteristics, European policies for their establishment and funding, and the organisational models of leading European centres in the field of plant systems biology.

The first part of the chapter analyses the nature and functions of Centres of Excellence. The findings indicate that they represent specialised research and innovation structures that concentrate human, financial, and technological resources to achieve high scientific performance and accelerate the knowledge transfer to the economy and society. The study demonstrates that Centres of Excellence simultaneously perform scientific, innovation, educational, and social functions and have become a key component of contemporary innovation ecosystems.

Based on the literature review, a classification of Centres of Excellence has been developed, according to which they can be categorised as research-oriented, technology and innovation-oriented, socio-political, and education-oriented. The analysis reveals that contemporary European models increasingly integrate these functions by combining fundamental research, applied development, technology transfer, and collaboration with industry and public institutions.

Particular attention is paid to the relationship between Centres of Excellence and the development of the bioeconomy. The analysis demonstrates that they act as strategic intermediaries between academia, industry, and the public sector by facilitating innovation, supporting human capital development, and fostering sustainable partnerships. In this context, Centres of Excellence can be regarded as institutional mechanisms for accelerating the transition towards a sustainable and circular bioeconomy.

The second part of the chapter examines European policies for the establishment and development of Centres of Excellence. The evolution of the European Research Area (ERA) and the European Union's Framework Programmes for Research and Innovation is reviewed. The analysis shows that Horizon 2020, Horizon Europe, and the Teaming, Twinning, and ERA Chairs instruments are specifically designed to reduce disparities in scientific capacity among Member States and to strengthen sustainable research infrastructures.

Particular emphasis is placed on the Widening Participation initiative, which seeks to enhance the scientific and innovation potential of countries with lower research and innovation

performance. The analysis indicates that, through the Teaming instrument, the European Union supports the establishment of Centres of Excellence by promoting strategic partnerships between institutions from Widening countries and leading international research organisations. This approach creates favourable conditions for building long-term institutional capacity, developing research infrastructure, and improving international competitiveness.

The study demonstrates that European policies regard Centres of Excellence not merely as a mechanism for financing scientific research but also as a strategic instrument for the structural transformation of national innovation systems, the development of human capital, and the strengthening of interactions among science, industry, and society.

A central focus of the chapter is the comparative analysis of four leading European Centres of Excellence in the field of plant systems biology:

- Centre of Plant Systems Biology and Biotechnology (Bulgaria);
- Max Planck Institute for Molecular Plant Physiology (Germany);
- John Innes Centre (United Kingdom);
- VIB–UGent Centre for Plant Systems Biology (Belgium).

The comparative study is conducted using a comparative case study methodology, encompassing organisational structures, scientific specialisation, governance mechanisms, international collaboration, contributions to the bioeconomy, and institutional sustainability.

The Max Planck Institute of Molecular Plant Physiology (MPI-MP), the Centre of Plant Systems Biology and Biotechnology (CPSBB), the VIB–UGent Centre for Plant Systems Biology (Belgium), and the John Innes Centre (United Kingdom) are compared across several key dimensions (Table 1). While these institutions share common features, they differ considerably in terms of scale, institutional integration, strategic positioning, and their contribution to the development of the bioeconomy (Max Planck Society, n.d.; Gechev et al., 2024; VIB, 2024; John Innes Centre, n.d.; John Innes Centre, 2024).

MPI-MP is organised into three scientific departments, complemented by several independent research groups and affiliated university units (Max Planck Society, n.d.; MPI-MP, n.d.). Approximately 400 researchers and staff members from numerous countries work at the institute (MPI-MP, n.d.). One of its principal scientific objectives is the development of advanced tools and the discovery of novel genes associated with plant metabolism and biomass accumulation. Its institutional profile is strongly focused on metabolic and molecular processes within plant cells and the interactions between genomes and organelles (Max Planck Society, n.d.). The life sciences community in the region is internationally recognised as a global centre of innovation and scientific excellence (Max Planck Society, n.d.; MPI-MP, n.d.).

As a leading plant biotechnology centre, the VIB–UGent Centre for Plant Systems Biology specialises in scientific research and innovation while also promoting capacity building and collaboration at both regional and global levels (VIB, 2024; VIB, 2025; VIB–UGent PSB, n.d.). Its research agenda is particularly focused on addressing the food security and nutritional needs of smallholder farmers through advanced plant science and biotechnology (VIB, 2025).

**Table 1. Comparative Analysis of the Institutional Models, Research Objectives, and Methodological Approaches of Selected European Centres of Excellence.**

| Dimension | CPSBB (Bulgaria) | MPI-MP (Germany) | VIB–UGent (Belgium) | John Innes Centre (United Kingdom) |
|---|---|---|---|---|
| **Institutional Model** | Independent institute; public-private structure; developed through the Teaming/PlantaSYST initiative and subsequent projects (Gechev et al., 2024; European Commission CORDIS, 2025; CPSBB, n.d.) | Publicly funded; independent institute within the Max Planck Society (Max Planck Society, n.d.; MPI-MP, n.d.) | Publicly funded; inter-university ecosystem and VIB–UGent partnerships (VIB, 2024; VIB, 2025) | Public research institute within the UKRI/BBSRC framework; independent institutional profile (John Innes Centre, n.d.; John Innes Centre, 2024) |
| **Main Research Focus** | Plant stress biology; systems biology; biotechnology; strong orientation towards applied research and knowledge transfer (Gechev et al., 2024; CPSBB, n.d.) | Plant metabolism; systems and computational biology; fundamental research programmes (Max Planck Society, n.d.) | Plant biotechnology; genomics; epigenetics; translational research programmes (VIB, 2025; VIB–UGent PSB, n.d.) | Crop genetics; plant–microbe interactions; synthetic biology (John Innes Centre, n.d.; John Innes Centre, 2022) |
| **Research Infrastructure** | Genomics and omics facilities; stress phenotyping platforms; greenhouses; IoT and field stations; Life Cycle Assessment (LCA) tools (Gechev et al., 2024; CPSBB, n.d.) | Advanced omics platforms; metabolomics; imaging systems; structured departments and research groups (Max Planck Society, n.d.; MPI-MP, n.d.) | High-throughput sequencing and proteomics; computational biology; translational research platforms (VIB, 2024; VIB–UGent PSB, n.d.) | Genome editing technologies; field trials; microbiome laboratories; translational capacity for crop breeding (John Innes Centre, n.d.; John Innes Centre, 2022) |
| **Scientific Approaches and Methods** | Functional genomics; transcriptomics; phenotyping; technology integration; Life Cycle Assessment | Multi-omics; systems modelling; advanced imaging technologies | Genome editing; synthetic biology; translational R&D approaches (VIB–UGent | CRISPR technologies; epigenetics; systems biology; microbial |

| Dimension | CPSBB (Bulgaria) | MPI-MP (Germany) | VIB–UGent (Belgium) | John Innes Centre (United Kingdom) |
|---|---|---|---|---|
| | (LCA) (Gechev et al., 2024) | (Max Planck Society, n.d.) | PSB, n.d.; VIB, 2025) | interactions (John Innes Centre, 2022; John Innes Centre, n.d.) |
| **Strategic Objectives** | Regional transformation and capacity building within the Widening context; accelerated knowledge transfer into practice (Gechev et al., 2024; European Commission CORDIS, 2025) | Scientific excellence and fundamental research (Max Planck Society, n.d.) | Scientific innovation and industrial engagement; technology transfer and entrepreneurship (VIB, 2024; VIB, 2025) | Food security; sustainable agriculture; crop improvement (John Innes Centre, n.d.; John Innes Centre, 2022) |
| **Role in the Bioeconomy** | High (strong applied orientation; provision of research capacity and services; regionalisation of innovation) (Gechev et al., 2024) | Moderate (more indirect contribution through fundamental science as a basis for future applications) (Max Planck Society, n.d.) | High (well-developed spin-off and technology transfer ecosystem; applied research platforms) (VIB, 2024; VIB, 2025; VIB Agribiotech, n.d.) | High (contributions to sustainable agriculture and crop breeding; significant patent and economic impact) (John Innes Centre, 2022; Nature, 2022) |
| **International Collaboration** | EU consortia; public-private partnerships; strong industrial linkages (European Commission CORDIS, 2025; CPSBB, n.d.) | Extensive international networks through the Max Planck Society and strategic partnerships (Max Planck Society, n.d.) | European research networks and industry collaboration; strong university integration (VIB, 2024; VIB, 2025) | Partnerships with scientific and applied research networks; broad international recognition (John Innes Centre, n.d.; John Innes Centre, 2022) |
| **Stage of Development** | Emerging and rapidly developing centre (Gechev et al., 2024; European Commission CORDIS, 2025) | Mature and globally recognised institution (Max Planck Society, n.d.; MPI-MP, n.d.) | Mature and internationally competitive institution (VIB, 2024; VIB, 2025) | Long-established institution with significant global impact (John Innes Centre, n.d.) |

Source: Author's own elaboration based on the literature review and strategic documents

Ghent University (UGent) has developed a large-scale research ecosystem and maintains close institutional integration with VIB (VIB, 2024). UGent actively promotes

interdisciplinary collaboration and supports research and networking activities without institutional barriers (VIB, 2024). Its international partnerships in plant biotechnology provide the organisation with a distinctive profile characterised by social responsibility and academic leadership (VIB, 2024; VIB, 2025).

The John Innes Centre (JIC) is a leading British Centre of Excellence in plant science and is internationally recognised as an independent research institute (John Innes Centre, n.d.). For more than a century, JIC has made substantial contributions to scientific knowledge, ranging from fundamental research to practical innovations (John Innes Centre, n.d.; John Innes Centre, 2022).

JIC is organised into numerous research groups and departments and maintains a strong capacity for knowledge and technology transfer (John Innes Centre, n.d.). The institute is distinguished by its successful transformation of scientific discoveries into widely adopted products and commercial ventures (John Innes Centre, 2022). The Centre contributes significantly to the development of the bioeconomy, particularly in the fields of low-carbon, plant-based chemicals and pharmaceutical products (John Innes Centre, 2022). In terms of global recognition, the John Innes Centre ranked among the world's top ten institutions for patent influence in 2022 according to the Nature Index Innovation ranking (Nature, 2022).

The organisational structure of CPSBB consists of administrative, technical, and IT units, as well as scientific and support departments (Gechev et al., 2024; CPSBB, n.d.). The administration is responsible for the Centre's administrative and financial management, communication with national and European institutions, and the coordination of its doctoral programme in biotechnology (CPSBB, n.d.; Gechev et al., 2024). An important aspect of its activities is the management of numerous national and international projects, thereby supporting both fundamental and applied research conducted within the Centre's scientific departments (European Commission CORDIS, 2025; Gechev et al., 2024).

Based on the data, CPSBB can be characterised as a newly established independent research centre operating for the public benefit (Gechev et al., 2024; CPSBB, n.d.; European Commission CORDIS, 2025). MPI-MP and the John Innes Centre are research excellence institutes functioning as independent public organisations integrated into the national frameworks of the Max Planck Society and UKRI/BBSRC, respectively (Max Planck Society, n.d.; John Innes Centre, n.d.; John Innes Centre, 2024). VIB–UGent represents a collaborative model combining a research institute and a university (VIB, 2024; VIB, 2025).

MPI-MP and the John Innes Centre are well-established institutions with long histories and substantial public funding, whereas CPSBB and VIB–UGent can be regarded as hybrid

organisational models (Max Planck Society, n.d.; John Innes Centre, 2024; Gechev et al., 2024; VIB, 2024). CPSBB represents an evolving public–private model with a strong regional orientation, while the other institutions operate within stable and mature governance systems (Gechev et al., 2024; Max Planck Society, n.d.; VIB, 2024; John Innes Centre, 2024).

In terms of scientific focus, all four organisations specialise in plant biology. CPSBB concentrates on biotechnological applications related to climate resilience and the bioeconomy (Gechev et al., 2024; CPSBB, n.d.). By contrast, MPI-MP's scientific contribution is centred on fundamental research in plant metabolism and systems biology (Max Planck Society, n.d.). The John Innes Centre focuses on sustainable agriculture, plant–microbe interactions, and synthetic biology (John Innes Centre, 2022; John Innes Centre, n.d.). VIB–UGent specialises in genomics and biotechnology with commercial applications (VIB, 2025; VIB–UGent PSB, n.d.). The comparison suggests that CPSBB has a stronger applied orientation towards the bioeconomy and technology transfer, whereas the other institutions maintain broader portfolios of fundamental and translational research (Gechev et al., 2024; Max Planck Society, n.d.; VIB, 2025; John Innes Centre, 2022).

Regarding research infrastructure, MPI-MP and VIB–UGent place particular emphasis on omics technologies and advanced imaging systems, whereas the John Innes Centre focuses on genome editing and field experimentation (Max Planck Society, n.d.; VIB, 2025; John Innes Centre, 2022). CPSBB supports commercial applications through IoT-enabled field stations and Life Cycle Assessment (LCA) tools (Gechev et al., 2024). While CPSBB is primarily oriented towards agroecological systems and technology integration, the remaining centres place greater emphasis on fundamental biology and the transition from laboratory research to field applications (Gechev et al., 2024; Max Planck Society, n.d.; VIB, 2025; John Innes Centre, 2022).

From the perspective of strategic objectives, CPSBB is still in a developmental phase and is primarily focused on institutional capacity building (Gechev et al., 2024; European Commission CORDIS, 2025). In contrast, MPI-MP prioritizes scientific excellence (Max Planck Society, n.d.). As a collaborative research ecosystem, VIB–UGent emphasises innovation and industrial engagement, while the John Innes Centre focuses on food security and sustainability (VIB, 2024; VIB, 2025; John Innes Centre, 2022).

CPSBB is closely linked to the development of the bioeconomy through biotechnology-driven transformation, whereas VIB–UGent and the John Innes Centre explicitly position their activities within the bioeconomy agenda (Gechev et al., 2024; VIB, 2025; John Innes Centre,

2022). MPI-MP contributes more indirectly through its strong emphasis on fundamental scientific research (Max Planck Society, n.d.).

CPSBB is an emerging organisation with strong connections to biotechnology companies and considerable regional development potential (Gechev et al., 2024; European Commission CORDIS, 2025). The remaining institutions are mature, internationally recognised, and globally competitive research organisations (Max Planck Society, n.d.; VIB, 2025; John Innes Centre, 2022; Nature, 2022).

The funding model of MPI-MP is based primarily on support from the Max Planck Society and is complemented by European research grants (Max Planck Society, n.d.; MPI-MP, n.d.). As one of the world's most prestigious and well-funded research organisations, the Max Planck Society provides stable institutional funding, while European grants add competitive project-based resources and facilitate international collaboration (MPI-MP, n.d.) (Table 8).

CPSBB is funded through the EU Teaming programme, national grants, and private investment (Gechev et al., 2024; European Commission CORDIS, 2025; CPSBB, n.d.). Its financial model relies predominantly on European capacity-building programmes designed to strengthen scientific excellence and institutional sustainability (European Commission CORDIS, 2025; Gechev et al., 2024).

The funding structure of VIB–UGent combines support from the Flemish Government, competitive European programmes, and industrial partnerships (VIB, 2024; VIB, 2025). Significant public investment provides long-term institutional stability, while European funding and industry collaboration stimulate innovation and applied research.

The John Innes Centre receives its core funding from UKRI/BBSRC, complemented by European projects and additional income streams reported in its annual financial statements (John Innes Centre, 2024; John Innes Centre, n.d.). The Centre benefits from strong national support, supplemented by charitable funding and other external sources that contribute to its overall financial sustainability (John Innes Centre, 2024).

A comparative assessment of the funding structures reveals significant differences in the composition of financial resources, reflecting national research systems, institutional mandates, and patterns of collaboration with external partners (John Innes Centre, 2024; Max Planck Society, n.d.; VIB, 2024; Gechev et al., 2024).

For the John Innes Centre (JIC), publicly available annual reports provide insight into the composition of total income and its reliance on the principal public sponsor, BBSRC/UKRI, while also highlighting the presence of “other income”, including competitive research grants and additional revenue streams (John Innes Centre, 2024; John Innes Centre, n.d.). This funding

structure underscores JIC's strong dependence on public support, while simultaneously demonstrating a substantial capacity to attract diversified non-governmental resources through partnerships, scientific services, and externally funded projects (John Innes Centre, 2024; John Innes Centre, 2022).

**Table 2. Comparative Analysis of the Funding Models and Scientific Impact of Selected European Centres of Excellence**

| Institute | Funding Sources | Global Scientific Significance |
|---|---|---|
| **MPI-MP** | Predominantly public institutional funding through the Max Planck Society (MPG), complemented by competitive and project-based funding (Max Planck Society, n.d.; MPI-MP, n.d.) | Globally recognised leader in plant science and fundamental research (Max Planck Society, n.d.) |
| **CPSBB** | Project-based funding through the EU Teaming programme and other European initiatives, supplemented by own revenues and service activities (Gechev et al., 2024; European Commission CORDIS, 2025; CPSBB, n.d.) | Emerging Centre of Excellence with growing regional significance in South-Eastern Europe (Gechev et al., 2024) |
| **VIB–UGent** | Public core funding from the Flemish Government, complemented by competitive European programmes and industrial partnerships with strong technology transfer activities (VIB, 2024; VIB, 2025) | Leading European player in plant biotechnology and translational research (VIB, 2025; VIB–UGent PSB, n.d.) |
| **John Innes Centre** | National funding primarily through BBSRC and other UKRI mechanisms, supplemented by project-based funding and additional income sources reported in annual accounts (John Innes Centre, 2024) | World-leading research institute with a strong translational profile and significant patent impact (John Innes Centre, 2022; Nature, 2022) |

Source: Author's own elaboration based on the literature review and strategic documents

In contrast, the funding model of VIB–PSB reflects its position within the highly integrated regional research ecosystem of Flanders. VIB emphasizes a structured funding strategy and close integration with universities, while PSB demonstrates a translational orientation through its spin-off ecosystem (VIB, 2024; VIB, 2025; VIB Agribiotech, n.d.). Industrial collaboration and technology transfer constitute structural elements of this model, as evidenced by publicly documented spin-off companies such as DevGen, CropDesign, Biotalys, Aphea.Bio, and Protealis (VIB Agribiotech, n.d.; VIB, 2025). This diversified, yet predominantly publicly funded model supports the dual mission of VIB–PSB: conducting fundamental research while delivering high-impact innovations (VIB, 2025; VIB–UGent PSB, n.d.).

MPI-MP represents a third model, characteristic of the financial architecture of the Max Planck Society, where a stable institutional funding base is complemented by competitive research projects and international talent mobility (Max Planck Society, n.d.; MPI-MP, n.d.). The institute's public profile as part of the Max Planck Society and its organizational structure, consisting of departments and research groups, provide a solid foundation for sustaining long-term fundamental research programmes (Max Planck Society, n.d.; MPI-MP, n.d.).

The financial model of the Centre of Plant Systems Biology and Biotechnology (CPSBB) is characteristic of an emerging research centre in Southeast Europe. CPSBB was established and developed through the Horizon 2020 Teaming/PlantaSYST initiative and subsequent programmes aimed at long-term sustainability and capacity building, with public project-based instruments serving as key drivers of its institutional evolution (Gechev et al., 2024; European Commission CORDIS, 2025). This reflects its integration into European research networks and its orientation towards scientific excellence and industry-oriented knowledge transfer within a regional context (Gechev et al., 2024; CPSBB, n.d.).

The findings indicate that MPI-MP and the John Innes Centre represent mature and autonomous institutional models characterized by stable public funding, a high degree of scientific autonomy, and long-term strategic planning. These characteristics create favourable conditions for conducting fundamental research and maintaining a high level of international scientific competitiveness.

In contrast, CPSBB and VIB–UGent operate as hybrid models that combine university collaboration, national support mechanisms, and participation in European research programmes. These models are characterized by greater organizational flexibility and closer interaction with business and society, while at the same time being more dependent on project-based funding and external conditions.

The analysis demonstrates that, despite differences in their organizational and financial models, all of the centres examined pursue research activities of significant societal and economic relevance and contribute to the development of the bioeconomy through scientific research, innovation, knowledge transfer, and international collaboration.

Particular attention is devoted to the Centre of Plant Systems Biology and Biotechnology as an example of the successful establishment of a research infrastructure within the framework of the European policy for widening participation and spreading excellence. The analysis suggests that its long-term sustainability will depend on strengthening international partnerships, diversifying funding sources, enhancing technology transfer activities, and deepening collaboration with industry.

The comparative assessment allows several key conclusions to be drawn. First, Centres of Excellence constitute an essential instrument for the development of the European research and innovation system. Second, European policies create a favourable environment for building research capacity and reducing regional disparities. Third, the organizational sustainability of these centres depends on achieving a balance between scientific excellence, effective governance, international collaboration, and engagement with business and society. Finally, the analysis confirms that Centres of Excellence can serve as strategic drivers of the bioeconomy by generating knowledge, fostering innovation, and creating sustainable scientific and economic ecosystems.

# CHAPTER THREE: ANALYSIS OF THE CENTRE OF PLANT SYSTEMS BIOLOGY AND BIOTECHNOLOGY

Chapter Three is devoted to the analysis of the Centre of Plant Systems Biology and Biotechnology (CPSBB) as an example of a successfully established research infrastructure and Centre of Excellence in Bulgaria. The study examines the institutional prerequisites for its establishment, organizational structure, scientific activities, international cooperation, financial sustainability, and contribution to the development of the bioeconomy. The analysis is based on official documents, annual reports, statistical data, scientific publications, and comparative assessments with leading European research centres.

The chapter begins with an analysis of the development of Centres of Excellence in Bulgaria within the framework of the Smart Specialisation Strategy and European research and innovation policies. The findings indicate that investments in research infrastructure have created favourable conditions for modernising the national research sector; however, their long-term sustainability depends on effective governance, international cooperation, technology transfer, and collaboration with industry. The analysis identifies the main challenges facing Bulgarian Centres of Excellence as limited commercialization of research outputs, insufficient industrial participation, and the need to diversify funding sources.

Special attention is devoted to the establishment and development of the Centre of Plant Systems Biology and Biotechnology. CPSBB was founded in 2015 as an independent research organisation under the PlantaSYST project within the Teaming for Excellence initiative of the Horizon 2020 programme. The Centre was established through a partnership between Bulgarian and German research organisations, with active support from the European Commission, the Bulgarian government, and the Municipality of Plovdiv. Its mission is to advance fundamental and applied research in plant systems biology and biotechnology, facilitate knowledge and technology transfer, and contribute to the development of the bioeconomy in Bulgaria and Europe.

The organisational model of CPSBB represents a new type of research institution in Bulgaria. Unlike the traditional structures of the Bulgarian Academy of Sciences and the Agricultural Academy, the Centre operates as an independent legal entity with a high degree of administrative and managerial autonomy. Its governance structure includes a General Assembly, an Executive Board, a Director, and an International Scientific Advisory Board, which provides independent expert evaluation of the Centre’s strategic development and scientific activities.

The scientific structure of the Centre comprises specialised research and service units in bioinformatics, molecular stress physiology, plant development, metabolomics, quantitative genetics, and plant biotechnology. Alongside fundamental research, CPSBB develops activities related to technology transfer, intellectual property management, and the provision of specialised scientific services to public and private organisations.

An important aspect of the Centre's development is the establishment of modern research infrastructure. Through European and national funding, CPSBB has developed a state-of-the-art research complex comprising laboratories, greenhouses, specialised facilities for high-tech equipment, and advanced research installations. The analysis indicates that this infrastructure enables internationally competitive research and creates favourable conditions for attracting highly qualified Bulgarian and international scientists.

Particular emphasis is placed on human capital development. CPSBB successfully attracts young researchers and international experts through competitive employment conditions, a modern research environment, and an active internationalisation strategy. In 2021, the Centre received accreditation to provide PhD education in the professional field of Biotechnology, thereby expanding its capacity to educate highly qualified specialists and strengthen its scientific potential.

The scientific productivity of CPSBB has also been analysed. The findings reveal a steady increase in the number of scientific publications and international research projects. The Centre publishes its research in prestigious international journals with high impact factors and actively participates in European and national research programmes. Comparative analysis demonstrates that, in terms of publications per researcher, CPSBB ranks among the leading research organisations both in Bulgaria and in comparison, with its European partner institutions.

The Centre's scientific activities are supported by an active project-based strategy. CPSBB currently participates as either coordinator or partner in a significant number of international and national projects funded through Horizon 2020, Horizon Europe, the Bulgarian National Science Fund, and other funding schemes. The analysis shows that project participation has become a key mechanism for strengthening the Centre's scientific capacity and international integration.

Special attention is devoted to the financial sustainability of CPSBB. The analysis demonstrates that the Centre pursues a policy of funding diversification, combining European and national project funding, public support, scientific services, and contracts with industry. Despite these positive developments, revenues generated from the commercialisation of

research outputs and technology transfer still account for a relatively limited share of total income, highlighting the need for stronger collaboration with industry and further development of innovation activities.

International partnerships and integration into the European Research Area represent another important dimension of the Centre's development. CPSBB maintains active cooperation with universities, research organisations, and companies across Europe and other regions of the world. Its international activities include joint research projects, researcher mobility, PhD training, participation in scientific networks, and the organisation of international scientific events. The analysis identifies international collaboration as one of the key factors contributing to the Centre's scientific visibility and competitiveness.

The analysis leads to the conclusion that CPSBB represents a successful model for the establishment and development of a Centre of Excellence in Bulgaria. Through its autonomous organisational structure, modern research infrastructure, international partnerships, and high scientific productivity, the Centre contributes significantly to the advancement of scientific research, innovation, and the bioeconomy. At the same time, its long-term sustainability requires further strengthening of technology transfer activities, expansion of collaboration with industry, and an increase in the share of self-generated revenues from innovation.

The main findings indicate that CPSBB has established itself as a leading research centre in Bulgaria and Southeast Europe, successfully fulfilling the role of an intermediary between fundamental science, applied research, and economic practice. The experience gained from its development can serve as a model for the establishment and management of other research organisations dedicated to advancing the bioeconomy and sustainable innovation.

Based on Bulgarian- and English-language survey samples, the study further examines the role of Centres of Excellence, and CPSBB in particular, in the socio-economic development of the region and their contribution to science and the bioeconomy.

The inclusion of two independent survey samples is methodologically justified in order to improve the representativeness and analytical reliability of the study. This approach enables the inclusion of both the national target group and international stakeholders engaged with the Centre's activities, thereby reducing the risk of language-related limitations in respondent participation.

The sample includes representatives from academia, higher education, the public sector, business, and other stakeholders with varying degrees of interaction with the Centre. Respondents include individuals with no direct professional involvement with CPSBB, as well

as experts with long-standing collaboration and practical experience, enabling a comprehensive assessment of the Centre's scientific, innovation, and societal impact.

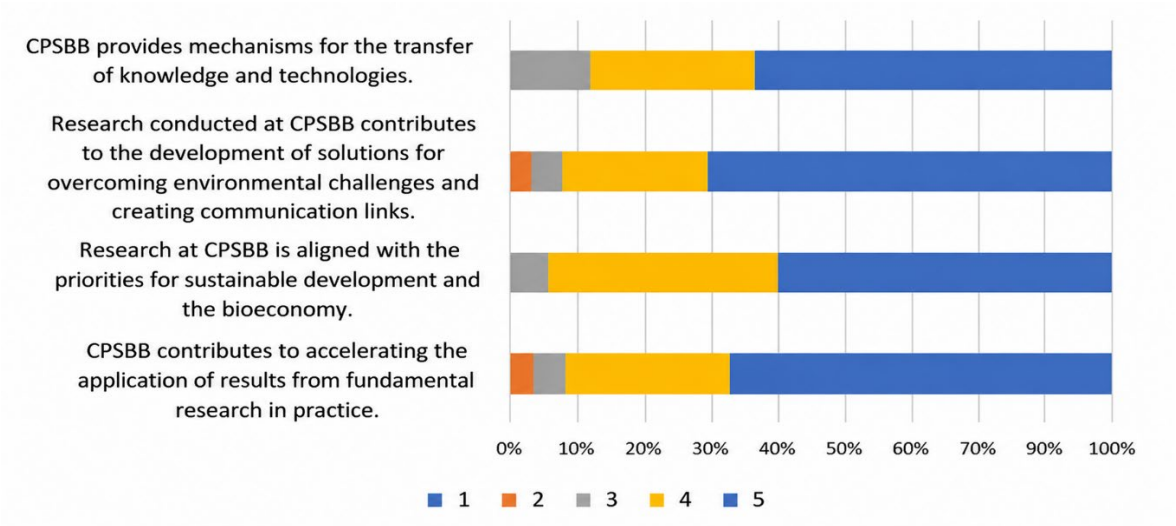
Regarding educational background, the majority of respondents hold higher education qualifications, with the largest groups consisting of individuals with Master's and PhD degrees. This suggests a high level of expertise and awareness concerning the subject matter of the study.

Differences are observed in the gender composition of the two subsamples. Female respondents predominate in the Bulgarian sample, whereas men account for the larger share (55.6%) of the international sample. This composition contributes to a broader representation of different perspectives in evaluating the Centre's activities.

The combined sample integrates internal expertise with independent external evaluation, enabling an assessment of both the direct effects of CPSBB's activities and its broader significance for the development of the bioeconomy at national and international levels. This provides a robust empirical basis for evaluating the Centre's contribution to scientific research, innovation, and sustainable development.

In summary, the comparative analysis demonstrates that the Bulgarian sample places greater emphasis on the Centre's applied and innovation-oriented impact, whereas the international sample highlights its scientific productivity and research infrastructure capacity. This distinction is particularly valuable for the dissertation, as it illustrates the Centre's dual role as both a generator of scientific knowledge and a driver of practical solutions for the bioeconomy.

**Figure 2. Scientific and Technological Impact (International Sample)**

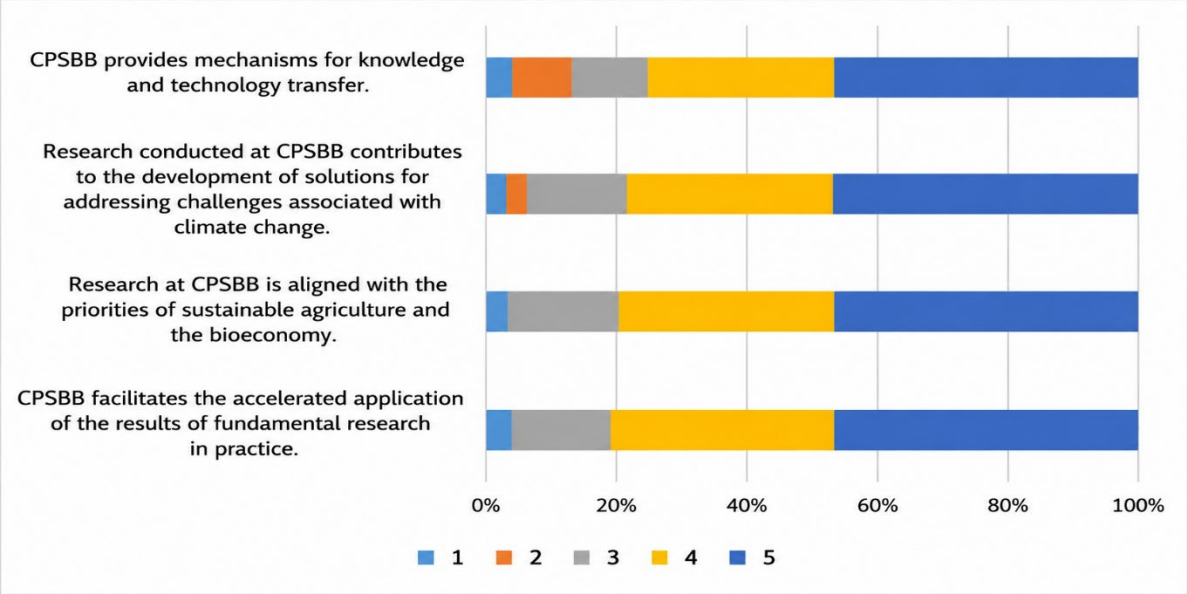



Source: Author's own survey

The analysis of the international sample is based on a five-point Likert scale (1 – strongly disagree; 5 – strongly agree) and reveals a clear concentration of responses at the upper end of the scale. This indicates a high level of agreement among respondents regarding the scientific and technological impact of the Centre of Plant Systems Biology and Biotechnology (CPSBB). The strongest positive evaluations relate to the Centre's contribution to addressing challenges associated with climate change and the alignment of its research with the priorities of sustainable agriculture and the bioeconomy. Although the highest ratings dominate, a certain proportion of responses fall within categories "3" and "4", suggesting a moderate degree of reservation, particularly concerning the effectiveness of knowledge transfer mechanisms and the rapid implementation of scientific results into practice.

The Bulgarian sample is also characterised by predominantly positive evaluations, although with a more noticeable presence of neutral responses compared to the international sample. This distribution reflects a more balanced and critical assessment by national respondents (Figure 3).

**Figure 3. Scientific and Technological Impact (Bulgarian Sample)**




Source: Author's own survey

The highest scores are again associated with the role of CPSBB in supporting sustainable agriculture and the bioeconomy, as well as its contribution to developing solutions to climate-related challenges. At the same time, the relatively larger proportion of ratings "3" and "4" for indicators related to knowledge transfer and the practical application of research

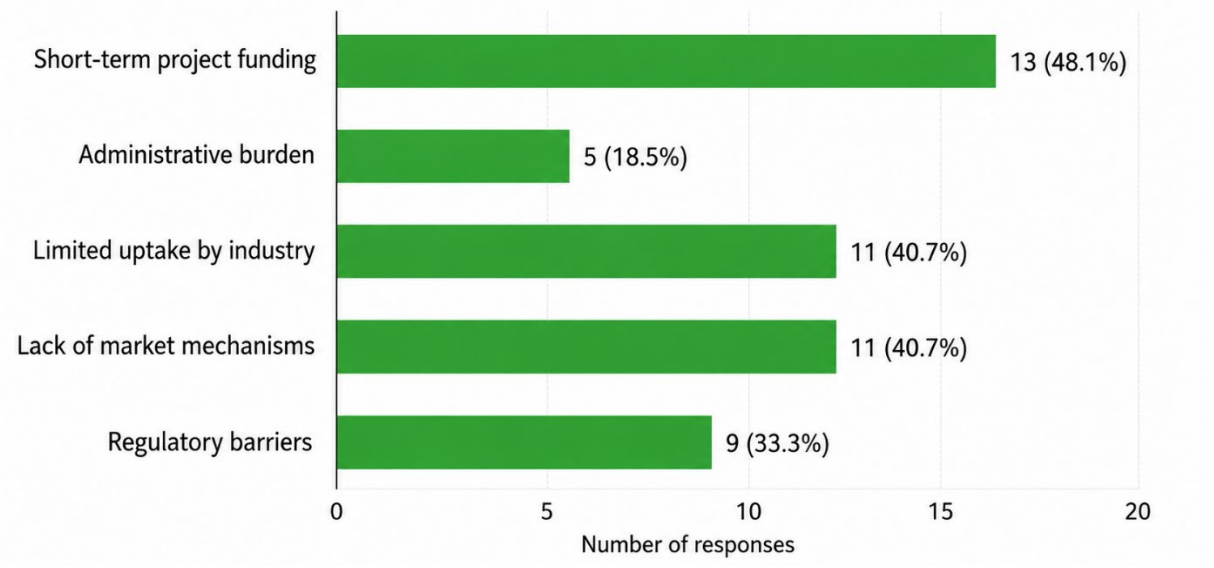
outcomes may be interpreted as evidence of existing limitations in the effective commercialisation and practical implementation of scientific achievements.

The comparative analysis of the two samples highlights differences in perception. International respondents demonstrate a higher degree of certainty in their positive evaluations, reflecting the Centre's strong reputation and favourable image in an international context. In contrast, Bulgarian respondents adopt a more moderate position, which is likely attributable to their greater knowledge related to the Centre's internal processes and the practical challenges associated with translating scientific outcomes into real-world applications.

Overall, the findings indicate a high level of agreement regarding the significance of the scientific and technological impact of CPSBB, while also identifying areas requiring further improvement, particularly with respect to knowledge transfer and the effective application of research results in practice.

The results further confirm a high level of institutional stability and confidence in the financial mechanisms supporting CPSBB. Nevertheless, the more moderate evaluations observed within the international sample suggest the need for enhanced communication regarding the Centre's long-term financial sustainability and strategic management in an international context (Figure 4).

**Figure 4. Main Limitations Affecting the Impact of the Centre of Plant Systems Biology and Biotechnology (CPSBB)**



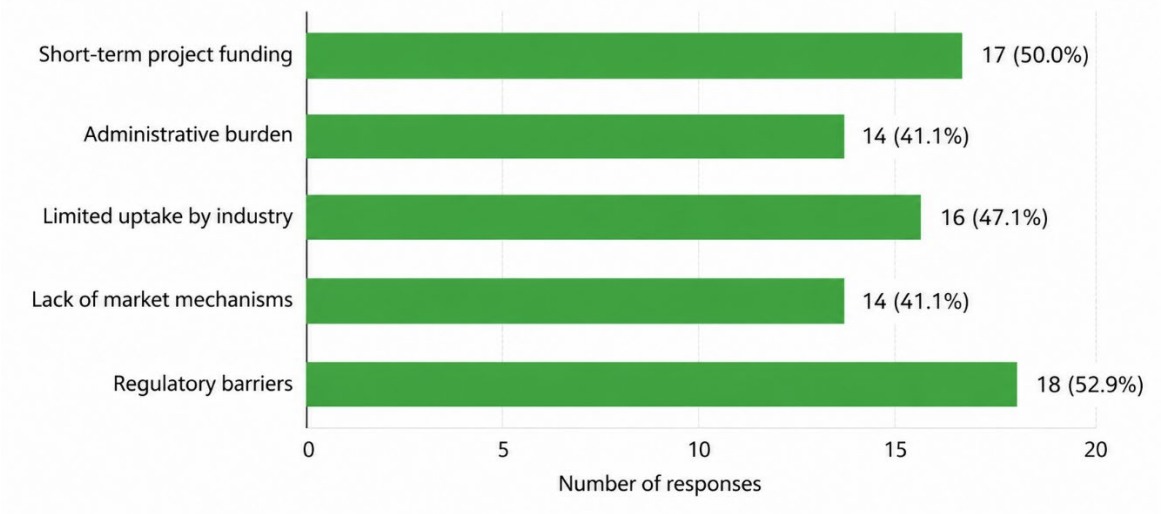

Source: Author's own survey

First, both samples identify the short-term nature of project cycles as a major constraint, although with differing levels of importance. In the international sample, this factor reaches

48.1%, while in the Bulgarian sample it accounts for 40.5%. These findings indicate that respondents in both contexts perceive the limited duration of project funding as a significant barrier to the sustainable development of research outcomes. The higher percentage observed internationally suggests greater sensitivity to the problem of disrupted scientific continuity following the completion of research projects, particularly in complex fields such as genomics, plant breeding, and biotechnological innovation, which require long-term investment and planning.

A substantial difference is observed with respect to administrative burden, which accounts for 18.5% in the international sample and 38.1% in the Bulgarian sample. This represents one of the clearest indicators of differences in the institutional environment. The considerably higher value in Bulgaria suggests that administrative procedures, reporting requirements, and regulatory obligations are perceived as much more significant obstacles to the efficient functioning of research infrastructures. In the national context, this is often associated with greater bureaucratic complexity, slower public procurement procedures, difficulties in human resource management, and regulatory requirements that reduce the operational flexibility of research organisations (Figure 5).

**Figure 5. Main Limitations Affecting the Impact of the Centre of Plant Systems Biology and Biotechnology (CPSBB)**




Source: Author's own survey

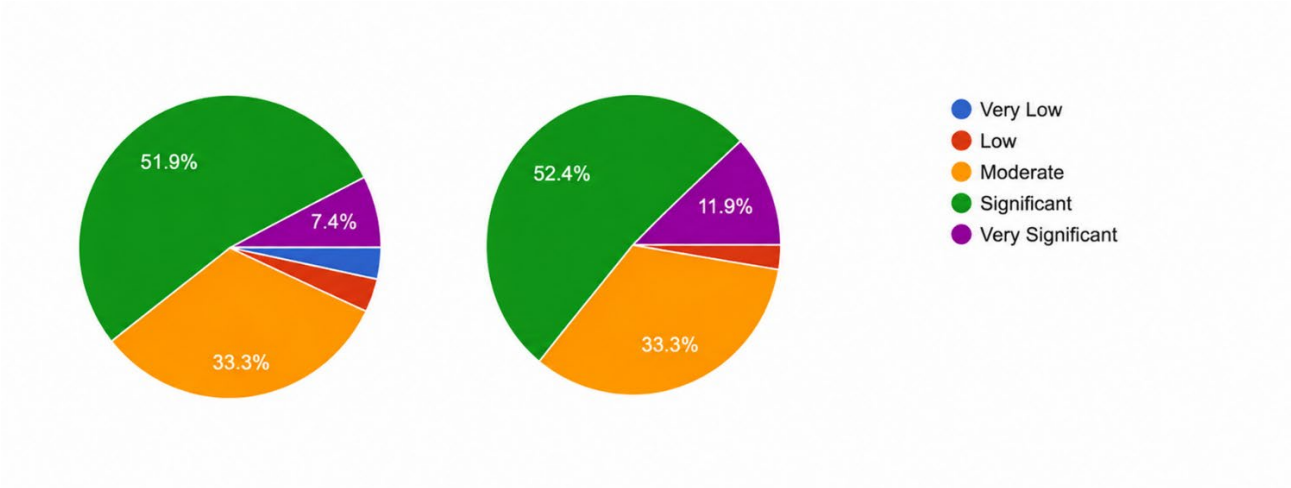
Regarding the limited uptake of research results by industry, the Bulgarian sample also reports a slightly higher value (42.9%) compared to the international sample (40.7%). Although the difference is relatively small, it highlights the continuing challenges in strengthening the relationship between science and business. These findings confirm that the transfer of scientific

results to industry, particularly within the agri-biotechnology and bioeconomy sectors, remains constrained by structural factors such as the limited innovation capacity of enterprises, insufficient demand for scientific services, and underdeveloped intermediary mechanisms.

A similar pattern is observed concerning the lack of market mechanisms, where the international sample records 40.7% and the Bulgarian sample 38.1%. The similarity of these values suggests that this issue is systemic rather than specific to the Bulgarian context. The absence of well-developed mechanisms for commercialisation, licensing, spin-off creation, and long-term industry partnerships limits the transformation of scientific achievements into tangible economic value.

The greatest difference between the two samples concerns regulatory barriers. While the international sample reports a value of 33.3%, the Bulgarian sample reaches 45.2%, representing the highest proportion within the national survey. This provides a strong indication that the regulatory framework in Bulgaria is perceived as one of the principal obstacles to the sustainability of research outcomes. Such barriers may include constraints related to intellectual property management, public procurement procedures, the use of research infrastructure, public funding regulations, and legal frameworks governing collaboration with the private sector.

**Figure 6. Overall Impact of the Centre of Plant Systems Biology and Biotechnology (CPSBB)**




Source: Author's own survey

From an academic perspective, the comparison between the two samples demonstrates that the international perspective places greater emphasis on the structural limitations associated with project-based funding, whereas the Bulgarian environment highlights administrative and regulatory barriers, together with institutional burden, as more significant constraints. These

findings confirm that the sustainability of Centres of Excellence depends not only on scientific capacity but also on the quality of the governance and regulatory environment within which they operate.

The figure provides an opportunity for a valuable comparative analysis of the overall impact of the Centre of Plant Systems Biology and Biotechnology (CPSBB) on the bioeconomy, as perceived by the international sample (left chart) and the Bulgarian sample (right chart).

In both samples, the dominant assessment is “significant”, accounting for 51.9% of international respondents and 52.4% of Bulgarian respondents. This nearly identical proportion is particularly noteworthy, as it demonstrates a high degree of consensus regarding the Centre’s strategic role in the development of the bioeconomy. From an academic perspective, this may be interpreted as empirical evidence that CPSBB is regarded as a sustainable institutional platform for generating scientific knowledge, innovation, and practical solutions with economic potential.

The second most important category in both samples is “moderate”, representing 33.3% of responses. This indicates that a considerable proportion of respondents also recognise the Centre’s positive contribution, albeit with a more cautious evaluation. This may reflect the fact that the effects of research infrastructures on the bioeconomy often emerge indirectly and over a longer time horizon through technology transfer, human capital development, the establishment of start-up companies, and regional specialisation.

An interesting difference is observed in the “very significant” category, where the Bulgarian sample reaches 11.9%, compared to 7.4% in the international sample. The higher national value suggests that Bulgarian respondents perceive the impact of CPSBB as stronger. This is understandable, as the Centre’s effects are more visible at the national level through improved research infrastructure, the creation of scientific networks, enhanced visibility of Bulgaria within the European Research Area, and the stimulation of the biotechnology sector.

At the same time, the categories “limited” and “very limited” account for only a small proportion of responses, particularly within the Bulgarian sample, indicating the absence of substantial scepticism regarding the Centre’s importance. The low percentages in these categories confirm that CPSBB has already established a high level of institutional trust and recognition as a key contributor to the development of the bioeconomy.

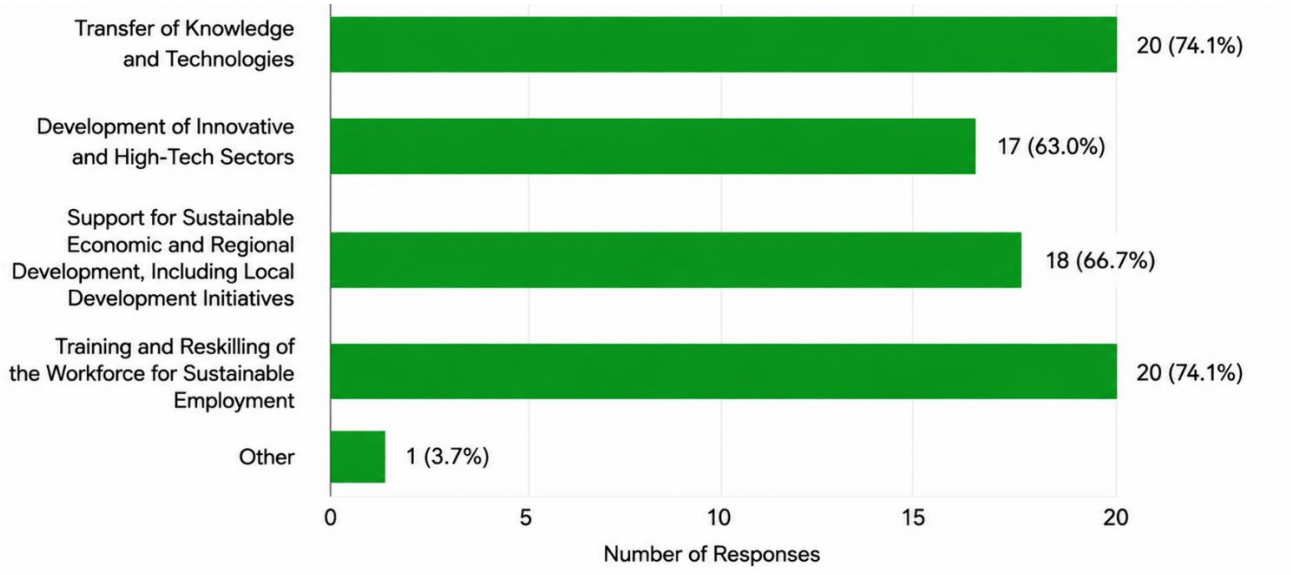
The findings demonstrate that the impact of Centres of Excellence on the bioeconomy extends beyond scientific output alone and encompasses broader systemic effects, including the

development of innovation ecosystems, regional positioning, technological modernisation, and the creation of favourable conditions for sustainable economic growth.

From a broader theoretical perspective, these results support the view that Centres of Excellence function as knowledge anchors within the bioeconomy—institutions that concentrate scientific knowledge, research infrastructure, human capital, and business linkages, transforming these assets into drivers of structural transformation and sustainable socio-economic development.

The results of the international survey indicate that respondents perceive knowledge and technology transfer and the training and retention of highly qualified scientific personnel as the most significant contributions of Centres of Excellence and Centres of Competence. Both indicators were identified by 74.1% of participants, highlighting the importance of scientific capacity and effective interaction between research organisations, businesses, and society. A high level of support was also expressed for contributions to sustainable economic and regional development, including local development (66.7%), as well as for the development of innovation and high-tech solutions (63.0%). Only 3.7% of respondents were unable to provide a specific assessment, suggesting a high level of awareness regarding the activities and significance of these research structures.

**Figure 7. Areas with the Greatest Potential for Future Impact – International Sample**




Source: Author's own survey

The findings demonstrate that public expectations of such centres extend beyond the generation of new scientific knowledge to its practical application through technology transfer, human capital development, and the stimulation of economic growth. The consistently high scores across all major indicators suggest a balanced perception of research centres as key drivers of competitiveness, innovation, and sustainable development at both national and regional levels. This confirms that their activities are regarded as an important instrument for building a knowledge-based economy and strengthening the links between science, education, and industry.

The highest-rated area in both samples is **"**Development of innovation and high-tech solutions", reaching 88.1%. This result is particularly significant, as it demonstrates a strong consensus that the Centre's innovation and technological capabilities will have the greatest future impact on the bioeconomy, the agricultural sector, and the science-based innovation environment. From an academic perspective, this supports the argument that Centres of Excellence are perceived not merely as research institutions but as drivers of technological transformation capable of generating new products, processes, and biotechnological solutions with substantial added value.

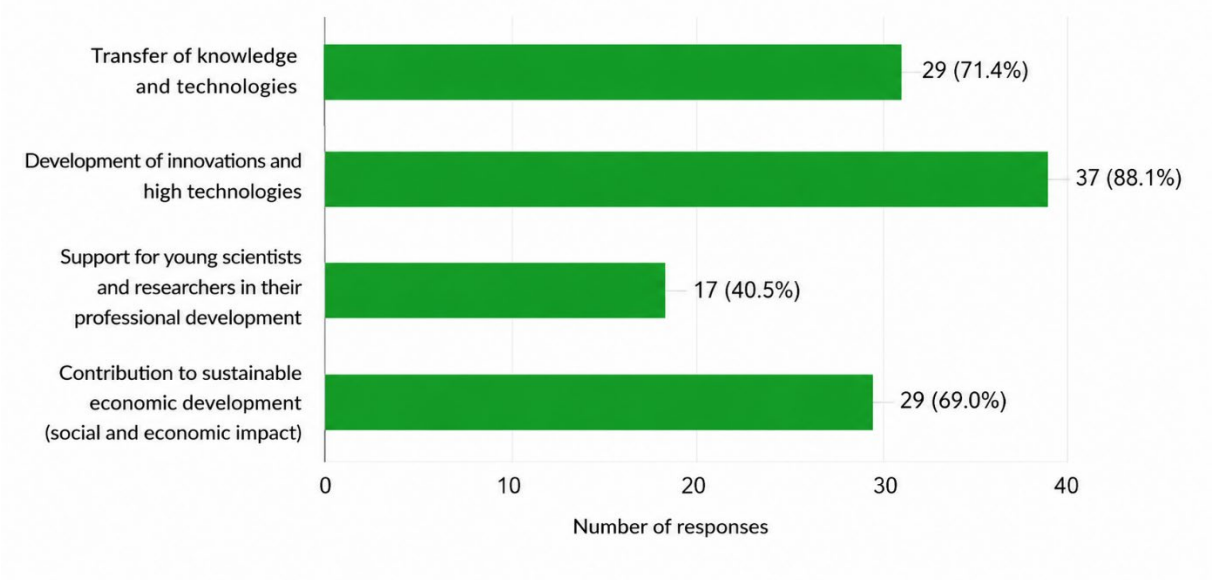
The second highest-ranked area is "Knowledge and technology transfer", with 71.4%, indicating that respondents attach considerable importance to the Centre's ability to transform scientific results into practical knowledge for businesses, the public sector, and agricultural practice. Within the context of the bioeconomy, this finding is particularly important because effective knowledge transfer determines the extent to which scientific achievements can generate tangible economic and social benefits (Figure 8).

The next most significant area is "Training of highly qualified scientific personnel", with 64.3%, highlighting that the Centre's future impact is associated not only with technological development but also with the sustainable reproduction of human capital. This is strategically important, particularly for Bulgaria, where the education and retention of young scientists, interdisciplinary specialists, and biotechnology experts remain essential factors for long-term competitiveness.

A lower, though still substantial, level of potential is attributed to **"**Support for sustainable economic and regional development" (40.5%). This finding suggests that respondents perceive regional and economic impacts as secondary outcomes arising from stronger areas such as innovation, technology transfer, and human capital development. In other words, sustainable regional development is viewed as a consequence of the successful functioning of the Centre's core scientific and innovation mechanisms.

The minimal proportion of responses in the "I do not know" category indicates a high degree of clarity and confidence among respondents regarding the Centre's future strategic priorities.

**Figure 8. Areas with the Greatest Potential for Future Impact – National Sample**




Source: Author's own survey

The comparative analysis of the two surveys reveals certain differences concerning the most significant contributions of Centres of Excellence and Centres of Competence to socio-economic development. Although all examined areas receive positive evaluations, changes are observed in their relative importance according to respondents' perceptions.

The most substantial shift concerns the perceived role of these centres in the development of innovation and high-tech solutions. While this aspect was identified by 63.0% of participants in the first survey, the proportion increased to 88.1% in the second survey, making it the leading priority. This finding reflects growing public expectations that research organisations should contribute directly to the development and implementation of innovative technologies with practical applications and high added value.

Knowledge and technology transfer maintain their leading importance in both studies. Support levels remain relatively stable, at 74.1% in the first survey and 71.4% in the second, indicating a consistent perception of research centres as key intermediaries between science, business, and society. This confirms the importance of effective knowledge exchange and the commercialisation of scientific results as prerequisites for economic development and improved competitiveness.

At the same time, a decline is observed in the perceived contribution to sustainable economic and regional development. While this indicator was supported by 66.7% of respondents in the first survey, its share decreased to 40.5% in the second. This trend may reflect a shift in public expectations towards more concrete and measurable outcomes of scientific activity, such as technological innovation and economic impact, rather than broader regional development objectives.

The training of highly qualified scientific personnel also remain important functions of Centres of Excellence, although the proportion of positive responses decreased from 74.1% to 64.3%.

Overall, the comparison of the two surveys demonstrates that respondents increasingly associate the activities of Centres of Excellence and Centres of Competence with the development of innovation, advanced technologies, and knowledge transfer, while socio-economic and regional effects are viewed as secondary outcomes. This trend is consistent with European policies promoting smart growth, digital transformation, and the development of a knowledge-based economy, in which research organisations play a key role in strengthening innovation capacity and fostering sustainable development.

The findings indicate that the greatest potential for future impact lies in innovation and high-technology solutions, followed by knowledge transfer and the development of scientific human capital. This aligns closely with the logic of the bioeconomy, in which technological breakthroughs, the commercialisation of scientific knowledge, and highly skilled human resources constitute the principal drivers of long-term structural transformation.

# CHAPTER FOUR: OPTIMISATION AND STRATEGIC DEVELOPMENT OF CENTRES OF EXCELLENCE

Chapter Four is devoted to the optimisation and strategic development of Centres of Excellence, with particular emphasis on the Centre of Plant Systems Biology and Biotechnology (CPSBB). Drawing upon the conducted empirical research, comparative analysis, and European best practices, the study identifies the principal challenges to their development and proposes measures to enhance their institutional, scientific, and financial sustainability.

The survey findings indicate that Centres of Excellence are perceived as key components of the research and innovation infrastructure and as important drivers of the bioeconomy. International respondents emphasise scientific productivity, modern research infrastructure, and human capital development, whereas Bulgarian participants place greater emphasis on the practical application of scientific results and their contribution to innovation and technological advancement.

The results demonstrate a high level of recognition for the scientific potential and societal significance of CPSBB while simultaneously identifying several major challenges:

- dependence on project-based funding;
- administrative and regulatory issues;
- insufficiently developed technology transfer;
- limited implementation of research results in industry;
- underdeveloped commercialisation mechanisms;
- the need for closer collaboration with industry.

In Bulgaria, the establishment of Centres of Excellence has been closely associated with efforts to modernise research infrastructure, improve the international competitiveness of research organisations, and strengthen the links between science, industry, and society. Within this context, the Centre of Plant Systems Biology and Biotechnology (CPSBB) represents an example of a research organisation that successfully integrates fundamental and applied research, innovation activities, and educational functions.

Despite the progress achieved, the sustainable development of such research structures requires the implementation of strategic management models capable of ensuring institutional stability, financial sustainability, and scientific competitiveness. In this regard, the present study proposes an integrated multi-component model for the strategic development of Centres of Excellence that combines several interrelated dimensions. The underlying logic of the model is

based on a systems approach, according to which the sustainable development of research organisations results from the interaction among multiple interconnected dimensions. The proposed conceptual framework views Centres of Excellence as complex research and innovation ecosystems operating within a dynamic environment characterised by global scientific competition, rapid technological change, and an increasing demand for sustainable economic and social solutions.

**Figure 9. Integrated Multi-Component Model for the Strategic Development of Centres of Excellence**


Source: Author's own research

Within the proposed conceptual framework, five key components determining the strategic effectiveness and sustainability of Centres of Excellence have been identified:

1. Institutional sustainability;
2. Financial autonomy;
3. Scientific competitiveness;
4. Innovation transfer and industrial integration;
5. Societal and regional impact.

These dimensions form an integrated system in which the development of each individual component influences the effectiveness of the others. Consequently, Centres of Excellence are viewed not merely as scientific institutions but also as drivers of innovation

ecosystems that generate scientific knowledge, technological solutions, and socio-economic benefits.

*Institutional Sustainability*

Institutional sustainability constitutes the fundamental basis for the long-term functioning of Centres of Excellence. It encompasses the establishment of a stable organisational structure, effective governance mechanisms, and a clear strategic vision for development.

In the case of CPSBB, the organisational structure has been established as an independent research organisation, providing a high degree of operational autonomy and flexibility in managing scientific activities. This independence enables faster decision-making, more efficient human resource management, and greater adaptability to the rapidly evolving scientific environment.

A further essential element of institutional sustainability is the availability of modern research infrastructure. As a result of investments under Horizon 2020 and national operational programmes, CPSBB possesses a state-of-the-art research complex comprising laboratories, specialised equipment, and greenhouse facilities for experimental research.

Institutional sustainability is also closely linked to human capital development. Attracting and retaining highly qualified researchers, including international scientists, represents a key factor for scientific productivity and international visibility.

*Financial Autonomy*

Financial sustainability is one of the most important factors underpinning the long-term operation of research centres. In many cases, research organisations are heavily dependent on public funding, making them vulnerable to political and economic fluctuations.

One of the principal strategic priorities of Centres of Excellence is the diversification of funding sources, including:

- European research programmes;
- National research funds;
- Industrial partnerships;
- Revenue from scientific services;
- Technology licensing.

In the case of CPSBB, funding is secured through a combination of European programmes, national projects, and industrial collaboration. Such a hybrid financial model

creates greater stability and enables investment in new research fields, infrastructure modernisation, and human resource development.

*Scientific Competitiveness*

Scientific competitiveness is a key indicator of the success of Centres of Excellence. It can be measured through:

- Scientific publications;
- Participation in international projects;
- Scientific citations;
- Patents and technological developments.

CPSBB demonstrates a high level of scientific productivity, having published more than 300 scientific articles in international high-impact journals since its establishment. Furthermore, the Centre participates in numerous international research projects contributing to the development of new technologies in plant biology, genomics, and biotechnology.

Scientific competitiveness is closely associated with the internationalisation of research activities. International cooperation facilitates knowledge exchange, access to global scientific networks, and participation in major international research initiatives.

*Innovation Transfer and Industrial Integration*

Modern research centres are no longer confined to fundamental research but play an increasingly important role in transferring knowledge to industry and the wider economy.

In this context, Centres of Excellence function as bridges between science and business.

CPSBB actively collaborates with numerous international companies in biotechnology, plant breeding, and agricultural technologies. Technology transfer activities are further supported by a specialised office responsible for intellectual property management and technology transfer.

*Societal and Regional Impact*

The final dimension of the proposed model examines the role of Centres of Excellence as drivers of regional development.

CPSBB makes a significant contribution to the scientific and innovation capacity of the Plovdiv region. The Centre cooperates with local universities, research institutes, and

companies, thereby supporting the development of a regional research and innovation ecosystem.

In addition to its research activities, CPSBB fulfils important educational functions through the training of Master's and PhD students, the organisation of specialised courses, and participation in international educational programmes.

In this way, Centres of Excellence become catalysts for regional development by contributing to job creation, the establishment of innovative companies, and the strengthening of regional scientific capacity.

The proposed integrated strategic development model demonstrates that the sustainable development of research organisations requires a balanced approach combining institutional stability, financial sustainability, scientific competitiveness, innovation transfer, and societal impact.

The integrated multi-component model for the strategic optimisation of Centres of Excellence provides a systematic framework for analysing and managing research organisations. By integrating institutional, financial, scientific, innovation, and societal dimensions, the model offers a comprehensive understanding of the factors determining the sustainable development of research centres.

The implementation of this model may contribute to improving the effectiveness of research organisations, strengthening their international competitiveness, and enhancing the connections between science, industry, and society.

Particular attention is devoted to the sustainable development of research organisations following the completion of Teaming programmes. Four principal mechanisms are proposed:

- a sustainable financial model;
- a hybrid funding model;
- a mechanism for reinvesting scientific revenues;
- an internal fund for scientific innovation.

The hybrid model combines public funding, industrial partnerships, and revenues generated from scientific services and technology transfer. It is envisaged that a portion of these revenues should be reinvested in research infrastructure, new scientific projects, and support for early-career researchers.

The study demonstrates that Centres of Excellence play a crucial role in the development of the European bioeconomy through the integration of fundamental and applied research, the acceleration of technology transfer, and the development of innovative products.

In the case of CPSBB, this contribution is realised through:

- the development of advanced research infrastructure;
- research in plant genomics and biotechnology;
- the development of sustainable agricultural technologies;
- the creation of bio-based products;
- collaboration with industry;
- the training of highly qualified specialists.

The Centre functions as the core of a regional innovation ecosystem, supporting the development of science, business, and public institutions.

The research findings indicate that the sustainable development of Centres of Excellence requires an integrated approach that combines institutional stability, financial autonomy, scientific competitiveness, technology transfer, and societal impact.

The proposed solutions may serve as a basis for the development of policies and strategies not only for CPSBB but also for other Centres of Excellence in Bulgaria and across Europe.

## CONCLUSIONS AND RECOMMENDATIONS

Based on the theoretical, comparative, and empirical research conducted on the impact of Centres of Excellence on the development of the bioeconomy in Europe, with a particular focus on the Centre of Plant Systems Biology and Biotechnology (CPSBB), the following key conclusions and recommendations can be highlighted.

CONCLUSIONS

- The study demonstrates that the bioeconomy constitutes a comprehensive transformational framework integrating scientific, technological, economic, and institutional processes aimed at the sustainable use of biological resources. Within this context, Centres of Excellence have emerged as key mechanisms for the generation and valorisation of knowledge.
- It is established that the role of Centres of Excellence extends beyond the traditional functions of research organisations, as they act as intermediaries linking fundamental science, applied research, industrial needs, and public policies.
- The comparative analysis of leading European centres reveals that their high level of effectiveness is based on a combination of strategic governance, sustainable funding, interdisciplinarity, international network integration, and professional technology transfer mechanisms.
- The study confirms that successful European models generate substantial benefits for bioeconomy through innovations in sustainable agriculture, biotechnology, plant genomics, bioactive compounds, and high-value functional products.
- The analysis of CPSBB demonstrates that it already fulfils the role of a national research and innovation hub in the fields of plant sciences, metabolomics, sustainable agriculture, and biotechnological solutions supporting the green transition.
- The empirical survey clearly indicates that Centres of Excellence, and CPSBB in particular, are perceived as key drivers of scientific and innovation development. Both respondent groups provide high evaluations of their contribution to the bioeconomy, sustainable agriculture, and addressing climate-related challenges, confirming their strong role as generators of knowledge and technological solutions.
- Distinct differences exist between the international and Bulgarian samples. The international perspective places greater emphasis on scientific productivity and research infrastructure, whereas the Bulgarian perspective focuses more strongly on practical

applicability, innovation, and technological risk reduction. These differences reflect variations in the maturity of innovation systems and the specific expectations associated with the Centre in the two contexts.

- The findings indicate that interactions with the Centre are primarily research-oriented; however, the Bulgarian sample demonstrates greater diversification through the involvement of business representatives, public administration, and entrepreneurial stakeholders. This suggests stronger integration of the Centre into the national innovation ecosystem and greater potential for knowledge transfer.
- Despite the predominantly positive evaluations, the survey clearly identifies structural constraints, including short-term project funding, administrative issues, regulatory barriers, and insufficiently effective technology transfer to industry. These findings indicate that the principal challenges facing Centres of Excellence are not related to a lack of scientific capacity but rather to the institutional and market environment in which they operate.
- The study confirms that the Centre's contribution to the bioeconomy extends beyond scientific publications and research projects to include human capital development, the establishment of collaborative networks, and the creation of practical solutions for the agricultural and biotechnology sectors.
- The research demonstrates that there remains considerable, although only partially realised, potential for transferring knowledge and technologies to industry, particularly in the areas of sustainable agriculture, climate-resilient crops, functional foods, and bio-based products.
- One of the principal conclusions is that the economic and societal value of Centres of Excellence depends critically on their ability to transform scientific results into patents, licences, spin-off companies, and industrial applications.
- The study identifies dependence on project-based funding as one of the major challenges facing Bulgarian Centres of Excellence, raising important questions concerning their institutional and financial sustainability after the completion of European funding programmes.
- The regional impact of CPSBB on Southern Bulgaria is shown to be of strategic importance through its contribution to the regional innovation ecosystem, collaboration with the agricultural sector, and support for smart specialisation.

- The research confirms that Centres of Excellence can become key instruments for achieving the objectives of the European Green Deal, digital transformation, and bioeconomy strategies.
- The findings indicate that the development of the bioeconomy in Bulgaria requires stronger integration among research infrastructure, industry, public institutions, and regional innovation policies.
- The study demonstrates that the long-term sustainability of Centres of Excellence should be regarded as a strategic issue within national research and innovation policy rather than merely as a temporary outcome of project-based funding.
- IThe findings clearly demonstrate that Centres of Excellence exert a substantial positive influence on the development of the bioeconomy in Europe and Bulgaria by accelerating scientific innovation, technology transfer, and regional specialisation.

RECOMMENDATIONS

- **A national long-term programme for the institutional sustainability of Centres of Excellence should be established to ensure their continued developmemt after the completion of major European funding programmes.**

The findings of the study clearly demonstrate that one of the most significant risks to the sustainable development of Centres of Excellence is their dependence on time-limited European funding schemes. In this regard, it is necessary to develop a national mechanism for long-term institutional support that would ensure the maintenance of established research infrastructures, the retention of highly qualified human capital, and the continuation of international research partnerships. Such a programme should provide predictability and strategic continuity, enabling the scientific capacities created through European initiatives to become permanent components of the national innovation system.

- **The establishment of professional technology transfer structures is recommended to support patenting, licensing, the creation of spin-off companies, and partnerships with industry.**

One of the key conclusions of the dissertation is that the actual contribution of Centres of Excellence to the bioeconomy depends largely on their ability to transform scientific results into applicable economic solutions. Therefore, it is essential to institutionalise specialised technology transfer offices that function as interfaces between research infrastructure and industry. These structures should possess expertise in intellectual property management, patent analysis, licensing agreements, entrepreneurial models, and the management of scientific spin-off companies, with the aim of accelerating the commercialisation of research outputs.

- **Sustainable financial models should be developed based on a combination of public funding, international projects, industrial contracts, and the commercialisation of intellectual property.**

To ensure the long-term financial sustainability of Centres of Excellence, a transition from predominantly project-based funding towards diversified financial models is required. This involves integrating multiple funding sources, including baseline public support, participation in international research consortia, contract research with the private sector, licensing revenues, and the establishment of spin-off enterprises. Such a hybrid funding model would reduce institutional vulnerability and enable more flexible strategic planning of both scientific and applied activities.

- **Centres of Excellence should be more closely aligned with the priorities of RIS3, the European Green Deal, and the national bioeconomy strategy.**

The research demonstrates that the potential of Centres of Excellence can be significantly enhanced through stronger integration with national and European policies on smart specialisation, green transition, and sustainable development. This requires positioning these centres as leading research and innovation platforms in priority areas such as agricultural biotechnology, climate-resilient agriculture, functional foods, bio-based products, and the circular bioeconomy. Such alignment would strengthen coordination between research policy, regional development, and economic specialisation.

- **Incentives should be introduced to encourage industrial partnerships in areas such as agricultural biotechnology, plant genomics, functional foods, and sustainable agriculture.**

To maximise the economic impact of scientific research, financial, fiscal, and regulatory incentives should be implemented to encourage active industrial participation in collaborative research with Centres of Excellence. Partnerships in strategic fields related to the biotechnological modernisation of agriculture, the development of new crop varieties and resilient agricultural systems, the creation of high-value products, and the improvement of food systems are of particular importance. Such measures would facilitate the accelerated transfer of research results into the real economy.

- **Specialised programmes should be developed to attract and retain young researchers, postdocs, and international scientists.**

Human capital represents the strategic resource determining the long-term competitiveness of Centres of Excellence. Consequently, targeted academic development programmes should be established to provide opportunities for career advancement, international mobility, interdisciplinary training, and participation in high-level scientific networks. Particular emphasis should be placed on attracting both Bulgarian and international early-career researchers through competitive remuneration, modern research infrastructure, and opportunities to develop independent research agendas.

- **Collaboration between Centres of Excellence and the agricultural sector should be expanded through living labs, demonstration farms, and pilot innovation platforms.**

Given the specific characteristics of the bioeconomy and the need for the rapid transfer of scientific knowledge into practice, the development of so-called *living labs*, demonstration farms, and pilot testing environments is of particular importance. These collaborative formats enable the validation of scientific innovations under real production conditions, the assessment of their economic feasibility, and their adaptation to the needs of the agricultural sector. In this way, an effective environment is created for the accelerated implementation of innovations related to sustainable agriculture, biotechnological solutions, and precision resource management.

## CONTRIBUTIONS OF THE DISSERTATION

### 1. Scientific and Theoretical Contributions

- An integrated theoretical and conceptual framework has been developed for analysing the interrelationship between the bioeconomy, Centres of Excellence, and innovation systems, combining the economic, institutional, and governance dimensions of sustainable development.
- A conceptual typology of Centres of Excellence has been developed, identifying their organisational characteristics, governance models, funding mechanisms, and functional linkages with the scientific, innovation, and economic environment.
- The role of Centres of Excellence as strategic intermediaries between science, industry, and public policy has been theoretically justified through the integration of the concepts of innovation systems and the Triple Helix model.
- The scientific understanding of Centres of Excellence as a key component of the European bioeconomy transformation has been further advanced by demonstrating their role in knowledge transfer, human capital development, and regional socio-economic development.

### 2. Scientific and Applied Contributions

- A comparative analysis of leading European Centres of Excellence in the field of plant systems biology has been conducted, identifying best practices, organisational models, and sustainability factors that can be adapted to the Bulgarian context.
- An empirical approach for assessing the role of Centres of Excellence in the development of the bioeconomy has been developed and validated through a bilingual survey, enabling the identification and systematisation of the principal factors determining their impact on innovation ecosystems and regional development.
- An integrated multi-component model for the strategic development and optimisation of Centres of Excellence has been developed, combining institutional, financial, scientific, and innovation mechanisms to support their sustainable operation.
- A business model and a strategic roadmap for the sustainable development of the Centre of Plant Systems Biology and Biotechnology (CPSBB), as well as for Centres of Excellence more broadly, have been proposed. These include mechanisms for ensuring financial sustainability, strengthening technology transfer, promoting international cooperation, and enhancing interaction among science, industry, and public institutions.

## PUBLICATIONS RELATED TO THE PhD THESIS

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6. **Kazakov, P., Atanasov, D., Beluhova, R., Mircheva-Topalova, M., Ivanova, A., Kazashka, V., & Gechev, T. (2026).** *Impact of Leading Plant Research Centres of Excellence on Scientific and Socio-Economic Development in Europe.* **Frontiers in Research Metrics and Analytics, 11**, 1770226. https://doi.org/10.3389/frma.2026.1770226