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System conditions supporting the development and commercialisation of innovative technological solutions

Key words

Technical support for sustainable development of the economy, technology transfer, strategic programme, commercialisation.

Słowa kluczowe

Techniczne wspomaganie zrównoważonego rozwoju gospodarki, transfer technologii, program strategiczny, komercjalizacja.

Summary

The article presents a systems approach to activities facilitating the development and commercialisation of innovative technological solutions supporting sustainable economic growth. The key aspects recognised by the authors are the determination and correlation of research directions of the future and the formation of strategies of action on both the micro and the macro level. Governmental strategic research programmes have been identified to be an effective formula for the realisation of research in generated research areas. The authors have emphasised the need for including activities providing systems support facilitating novel technologies transfer in research programmes of a strategic nature, along with the tasks for the development of innovative product and process solutions. The article also presents an example of an effective correlation of this type of problems in a currently realised research programme.

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Generation of research directions of the future

Economic innovativeness and competitiveness are determined by an effective realisation of strategies for economic and scientific development on a macroeconomic, national, and a microeconomic level that is the research institution's level. At the time of forming and realising the aforementioned development strategies, critical roles are played by the identification of future research directions and the generation of short- and long-term trends in the development of advanced technologies. The determination of research directions of the future is also of key importance from the perspective of a research institution, because it supports the design of a short-, medium-, as well as long- thematic scope and strategy of its R&D activity. Practical application of the results of undertakings like foresight projects enables the research for whose realisation a given institution has enough appropriate substantial, infrastructure and financial potential. Additionally, it allows the realisation of tasks directed at the development of the potential for the launching of future research directions included in a long-term strategy of a given scientific organisation complying with a national development strategy. The determined research directions and technologies are updated with the use of state-of-the-art analyses and expert analyses, in which the latest R&D trends and the results of sectoral and national foresight projects and national and EU strategic research priorities are taken into consideration. The means of generating research directions for R&D institutions considering their potential and the national priorities of strategic importance is depicted in Fig. 1.

Factors determining the selection of research directions realised at a research institution are composed, on the one hand, of national strategic research directions and, on the other hand, the potential, expert knowledge and experience of a given research institution in a particular research domain. In the case of a lack of necessary personnel, infrastructure and financial potential, particularly when referring to emerging technologies, activities directed at the development of the potential with a view of research directions planned for future realisation are undertaken on the institutional level.

The lack of conformity between research directions realised by a given research institution and the national research directions of strategic importance results in institutions desisting from the realisation of research in a particular domain or searching for alternative means of financing, i.e. in the case of R&D tasks with great commercial or application potential. Financial means for the realisation of such tasks can come from the institutions own financial resources, from the industry, or from special funds including those within international cooperation.

Therefore, the scope of nationally realised research is not the sole result of bottom-up procedures undertaken by research institutions in selected, strategically important, research directions. In the case of national needs, special mechanisms,

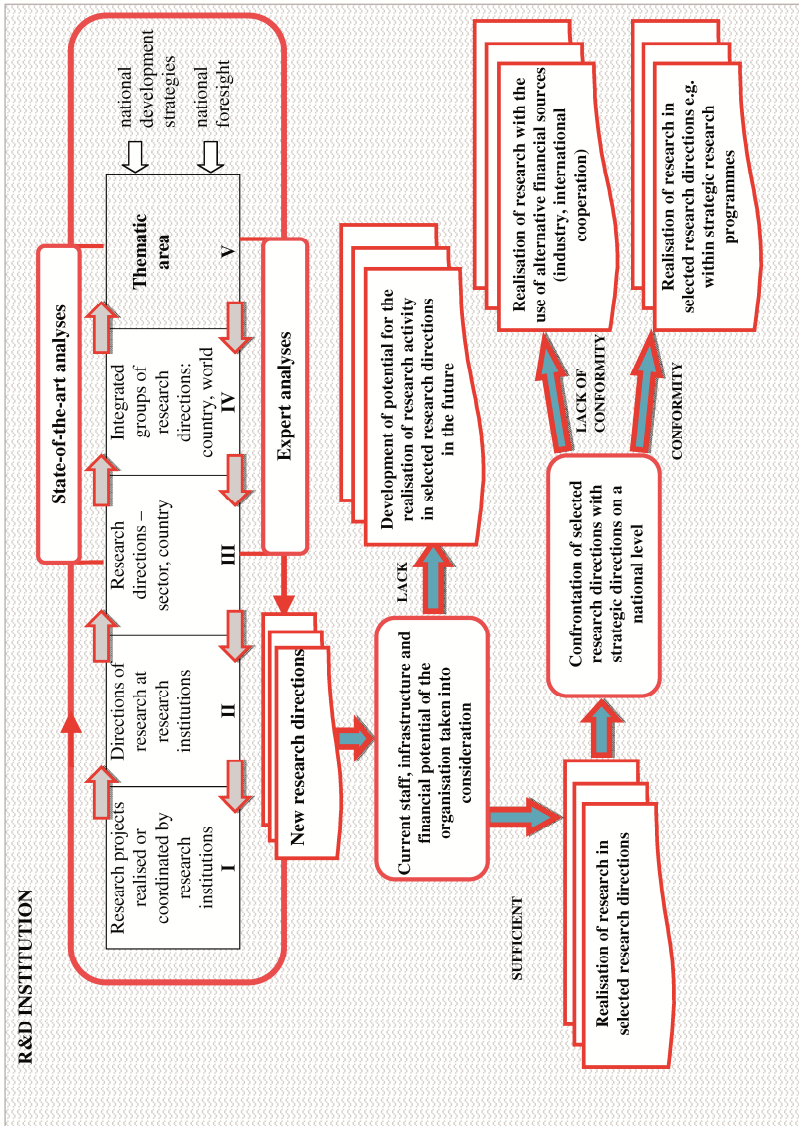


Fig. 1. Diagram of research results generation for research organisations
 Rys. 1. Schemat generowania kierunków badań jednostki badawczej

Source: Authors

e.g. strategic programmes facilitating the research in key domains or special structures (e.g. spin-offs, national research institutes) dedicated to the development of priority areas may be applied.

Generation of thematic areas of strategic research programmes

Directions of nationally realised priority research are generally determined by national strategies for economic and scientific development, whose creation is supported by, *inter alia*, the application of research results of foresight projects. The areas of strategic importance to the economic growth of a country are supported on a national level. The priority domains selected on a macro level ought to be narrowed down within sectoral foresight projects aimed at the identification of key technologies and visions of future development. Strategic directions on a national level and their specification conducted within sectoral foresight projects are then taken into consideration within corporate foresight projects directed at the determination of future research areas for a research institution or an enterprise (Fig. 2).

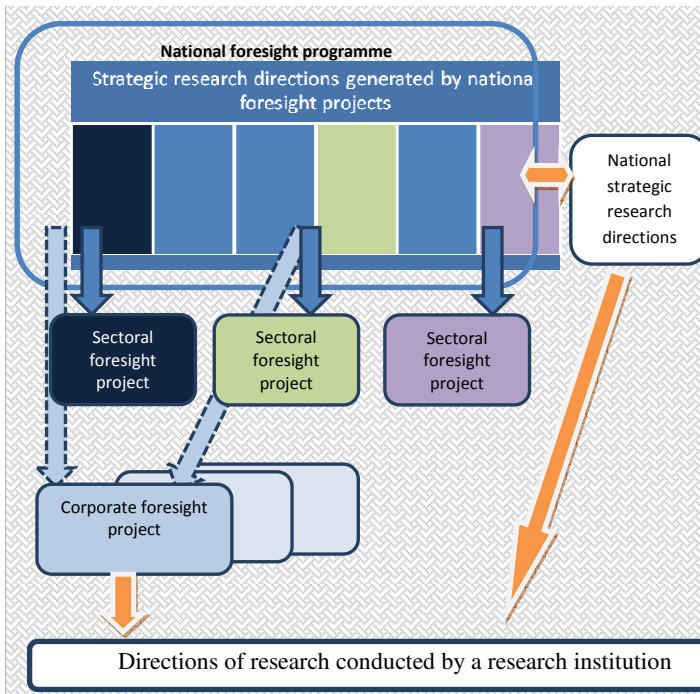


Fig. 2. System for the selection of research directions realised at a research institution with consideration of thematic areas generated within foresight projects

Rys. 2. System doboru kierunków badań prowadzonych w jednostce badawczej z uwzględnieniem tematyki wygenerowanej w ramach projektów foresight

Source: Authors

Joint consideration of the results of different kinds of foresight projects (national, sectoral, corporate) and the directions of research conducted at a research institution, including those carried out within national research programmes, enables the identification of the thematic areas of strategic research programmes (Fig. 3).



Fig. 3. Generation of subject matter of strategic research programmes
Rys. 3. Generowanie tematyki programów strategicznych

Source: Authors

The presented system approach has been applied in the determination of future research directions for the Institute for Sustainable Technologies – National Research Institute (ITeE – PIB), Radom, in the area of technical support for sustainable development, as a result of which the Strategic Programme has been generated.

The subject matter of the Strategic Programme has been determined by, on one hand, priorities indicated in EU and national strategic documents, thematic areas of governmental programmes of strategic importance, and priorities of a national foresight programme, and on the other hand, by the results of a sectoral foresight project including the subjects of advanced industrial and environmental technologies [4, 6] and the results of a corporate foresight project, conducted by ITeE – PIB [11].

Strategic Programmes as a formula for the realisation of research in domains of key national importance

Research programmes, including strategic programmes, are an acclaimed and widely applied form for the realisation of R&D activity directed at increasing national economic competitiveness by means of developing

innovative products and services, as well as the realisation of development tasks facilitating finding solutions to scientific, technical and organisational problems.

The subject matter of strategic programmes results from the scientific and innovative policy of a country and complies with national priorities indicated in strategic documents [1, 2, 3].

The Multiyear PW-004 Programme “Development of Innovative Systems of Manufacturing and Maintenance 2004–2008”¹ constitutes an original example of a strategic programme supporting sustainable development of the economy. The Programme encompassed a wide thematic scope particularly concerning system conditions and the generation of innovative solutions in the area of advanced products and manufacturing and maintenance technologies. Additionally, the Programme included the topics of technologically advanced, high-quality products, which include the following: test apparatus; material technologies; energy and material saving production systems; development of technical devices for the monitoring, prevention and elimination of technical threats; systems that decrease environmental strain caused by manufacturing processes, machine maintenance; and, the development of methods for quality support in technological manufacturing processes [10].

Apart from its material effects, the PW-004 Programme was a source of useful information and experiences concerning the realisation of actual innovative processes. The conducted technological research tasks formed the basis for the verification of developed methods of implementation maturity and commercial potential assessment. Application of these methods allowed full identification of material effects of the Programme with the view of their practical application readiness.

The realisation of the strategic PW-004 Programme has significantly contributed to the identification of the most crucial research and application needs concerning leading research directions in the area of innovative support of sustainable development of a country. On this basis, considering the results of national foresight projects (“Poland 2020” National Foresight Programme) [7, 9], sectoral foresight projects (“Advanced Industrial and Ecological Technologies for the Sustainable Development of Poland”) [4, 6] and corporate foresight projects (corporate foresight for ITeE – PIB) [11], priority research areas of the next Strategic Programme (“Innovative Systems of Technical Support for Sustainable Development of Economy”)² have been identified. These areas include priority R&D directions selected by the “Sustainable Development of Poland” research panel coordinated by the authors of the article within “Poland 2020” National Foresight Project. Research directions were then

¹ Established by the decision of the Polish Ministry Board (NR 97/2004) as an executive for strategic governmental research programmes for the benefit of the growth of national innovativeness, generated in the realisation of the policy of national economic development described in „Entrepreneurship-Development-Work” programme document [8].

² Realised in the 2010–2014 period, financed within Innovative Economy Operational Programme.

made more detailed within the sectoral foresight in which priority technologies of the future and the visions of their development were additionally determined. Both the research directions and the technologies have been included in the subject matter of the currently realised Strategic Programme.

Scope of problems within the strategic programme in the area of technical support for sustainable development of the economy

The “Innovative Systems of Technical Support for Sustainable Development of Economy” Strategic Programme aims at the development of both advanced product and process solutions ready for practical industrial implementation in the area of manufacturing and maintenance of technical objects and system solutions supporting their application.

The R&D matters revolve around five main thematic areas concerning advanced technologies facilitating manufacturing and maintenance processes, methods and systems of rational waste utilisation; systems for safe maintenance of technical objects, test apparatus and unique technological devices, knowledge transformation and technology transfer systems enabling technical and operational support for undertaken technological tasks, and a successful application and commercialisation of achieved research results.

The thematic areas concerning technological issues included in the Programme reflect the thematic areas of the aforementioned sectoral foresight project – “Advanced Industrial and Ecological Technologies for the Sustainable Development of Poland.” The Strategic Programme connects the two thematic areas of the foresight project, that is the area of materials technologies and nanotechnologies as well as mechatronics and control systems into one compound domain of advanced technologies supporting manufacturing and maintenance processes of technical objects. This has been an intentional action, since both solutions in the area of materials and mechatronic technologies are directly applied in the industry with view of the development of innovative commercial products.

The subject matter of the Programme also includes the “Systems of knowledge transformation, advanced technologies transfer and commercialisation of innovative solutions for sustainable economy” group in which issues including the continuation of foresight undertakings, mechanisms and structures of knowledge transformation and commercialisation of innovative results of strategic programmes are contained. The incorporation of this additional thematic group in the structure of the Strategic Programme results from the fact that it has been identified by the national and sectoral foresight project to be of great importance to economic growth. In “Poland 2020” National Foresight Programme, for instance, novel methods of knowledge transformation, technology transfer and innovation commercialisation have been

identified to be one of the strategic directions in the socio-organisational domain and considered to be decisive determinants of the growth of innovativeness and competitiveness of the national economy. Moreover, the Strategic Programme also includes the aspects of continuing education facilitating knowledge transformation and technology transfer processes as well as issues of staff training. The selection and incorporation of these themes into the subject matter of the Strategic Programme also stems from the effects and recommendations of the sectoral foresight project concerning the qualification and competencies of specialists designing, developing and implementing cutting edge, priority technologies.

Supporting the development and commercialisation of innovative technological solutions within the Strategic Programme

An effective realisation of strategic programmes requires close interactions and connections between its research tasks and activities for the systems support in the area of knowledge transformation and technology transfer as well as activities for the organisational support in the form of organisational and informational platforms aimed at the development and dissemination of innovative solutions (Fig. 4).

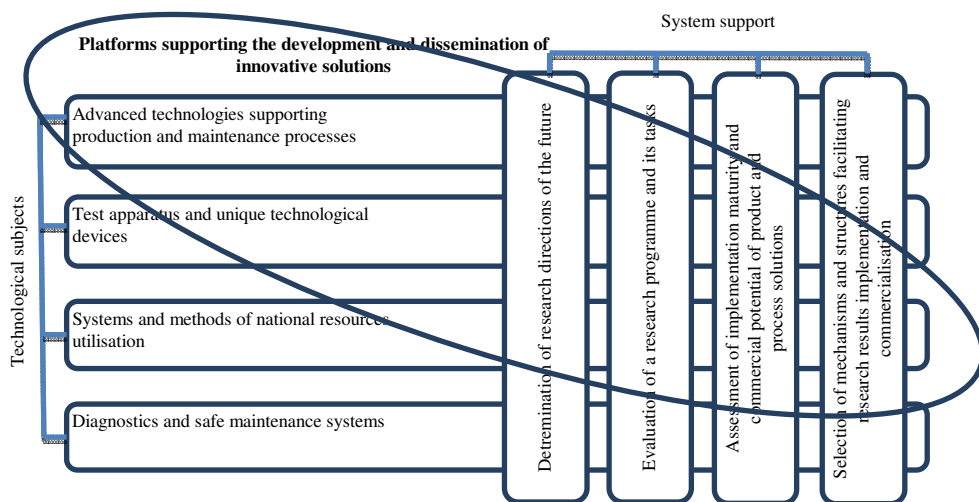


Fig. 4. Correlation of the realisation of research tasks of technological nature with activities providing system support in the area of knowledge transformation and technology transfer and organisational support

Rys. 4. Powiązanie realizacji zadań badawczych o charakterze technologicznym z działaniami zapewniającymi wsparcie systemowe w zakresie transformacji wiedzy i transferu technologii oraz wsparcie organizacyjne

Source: Authors

Tasks in the area of improving the efficiency of knowledge transformation and technology transfer processes undertaken within the Strategic Programme include the following interrelated issues:

- Determination of future research directions,
- The evaluation of strategic research programmes,
- Implementation maturity and commercial potential assessment,
- Search for effective mechanisms and structures for innovation deployment,
- The creation of organisational and informational platforms facilitating cooperation and dissemination of innovative solutions, and
- The education of personnel developing and using advanced technologies.

Selection of research directions of the future and priority technologies on the institutional level (level of research institutions), their updating and monitoring is of crucial importance to the functioning of such an institution. Tasks incorporated in the Strategic Programme are focused on the key aspects of future R&D directions identification, including the issues of generating key factors determining the way the research is conducted, rating of technologies with view of their innovativeness and competitiveness, and issues concerning scenario probability determination.

Realisation of research in generated directions and their results are subject to cyclical evaluation, which is an integral part of research programme management. The objective of the evaluation is to stimulate the increase in the effectiveness of implemented programmes and to indicate how undertaken tasks can be of use to the economy. Additionally, evaluation is directed at the assessment of the results of a realised programme, improvement of substantial effects, planning of further tasks, the assessment of current effectiveness and analysis of the quality of programme management. From the point of view of the national economy, evaluation of research programme results is of greatest importance, particularly when focusing on the possibility of practical application of the material effects of the programme. Unfortunately, the stage of practical application and industrial deployment of programme results is rarely included in its realisation, and the effects of research projects are not assessed with view of their commercial potential and industrial application efficiency. Thus, within the Strategic Programme realised, the assessment of implementation and commercial potential of its product and process results has been proposed. This assessment can be conducted with the use of an original method of the assessment of the implementation maturity of innovative solutions [5] that identifies the phase of the advancement of the solution and assesses the level of its innovativeness and practical deployment readiness. The assessment focuses on technological aspects but also concerns the advancement of R&D activity. It also allows planning the rational time, costs, and future actions regarding the application and maintenance of the innovative solution obtained. A high level of implementation maturity of a solution is a necessity for its practical implementation.

In order to be able to practically apply innovative product and process solutions, suitable mechanisms and structures supporting the phase of implementation and commercialisation need to be used. In Poland, the lack of effective practical implementations is a result of weak mechanisms and structures facilitating technology transfer. Despite a great number of innovative solutions developed and a variety of mechanisms and structures available, no effective system for innovation implementation has yet been developed in Poland. The most advanced and highly promoted by the Polish government technology transfer mechanism nowadays are the mechanisms of direct sale or spin-off venture creation; however, the latter still battles with numerous obstacles of a different nature.

The objective of research realised in the Strategic Programme is to indicate effective mechanisms and structures of knowledge transformation and technology transfer and to practically verify them with regards to technological solutions developed within the Programme.

One of the tasks supporting the practical implementation of developed cutting edge solutions is the activity directed at their dissemination, which can be achieved by means of organisational and informational platforms launched within the Programme. The organisational platform is a kind of network between all the subjects employed in the realisation of the Strategic Programme and the subjects participating in its research and applicatory results. The platform aims the realisation of promotional and marketing tasks directed at popularisation of innovative results of the Programme. The platform for research results dissemination is supplemented by the informational platform that, by means of computer tools, supports processes of knowledge transformation and technology transfer. The platform has a multilayer informational-operational structure directed at the diffusion of innovative product and process technologies and results of the Strategic Programme. The communication module between platform's users, who are members of interdisciplinary research teams, research institutions and enterprises, is one of the elements of the platform.

The key element necessary for the development of innovative solutions is the personnel responsible for the development of innovative solutions and the staff practically implementing them in enterprises. The tasks realised within the Strategic Programme are directed at the development of educational curricula and technologies facilitating the growth of competencies and qualifications and promoting professional and educational mobility of advanced technologies specialists directly participating in the creation of innovative solutions within the Strategic Programme as well as final end users of these solutions. Realised tasks additionally aim at the development of the project of the system for human resources development within Polish enterprises specialising in innovative activity. Their objective is to share the knowledge, forming the basis for the design of support directions in the range of minimisation of competence gaps the personnel have in the area of knowledge transformation and technology transfer.

Conclusions

The nationally undertaken systematic action for the support of research development and the practical application of research results are manifested in the consideration of foresight results at the time of the generation of strategic R&D directions to be realised, *inter alia*, in the form of strategic research directions. Effective application of results of foresight projects on national, sectoral, and corporate levels requires the correlation of their subject matters and realisation methodologies. The results of foresight projects should be incorporated into strategic programmes covering the subjects of innovative product and process solutions and including necessary system tasks supporting knowledge transformation and technology transfer. Practical application of developed solutions is enabled by the application of methods and tools allowing, among others, the assessment of developed solutions in the aspect of their commercial and implementation capabilities.

The experience of the authors of the article gained in the realisation of numerous research programmes, i.e. multiyear and strategic programmes, indicates the importance of these types of activities. The development of any innovative solutions faces a number of substantial, technical and organisational obstacles that may be the result of the necessity of developing novel solutions, coping with tight deadlines, organising effective and dynamic cooperation between the R&D sector and the industry, etc. However, currently, the most difficult problem to overcome is the transferring of research results into economic practice. Thus, the effective realisation of strategic programmes and the practical application of their results require the consideration of system solutions supporting knowledge transformation and technology transfer.

Interrelation between the process of technology development and system solutions supporting it is one of the features of the currently realised “Innovative Systems of Technical Support for Sustainable Development of Economy” Strategic Programme in which strategic national directions, future research directions selected with foresight projects and the potential of institutions realising it are all taken into consideration. Tasks related to systems support undertaken within the Programme aim at supporting practical applications of the results of the programme and creating and developing cooperation networks between the R&D sector and the industry, which is facilitated by the design of organisational and informational platforms. Realisation of tasks in the area of knowledge transformation and technology transfer contributes to effective dissemination, commercialisation, and implementation of technological and organisational results of the Programme.

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Systemowe uwarunkowania wspomaganie rozwoju i komercjalizacji innowacyjnych rozwiązań technologicznych

Streszczenie

W artykule zaprezentowano systemowe podejście w odniesieniu do prowadzenia działań stymulujących rozwój i komercjalizację innowacyjnych rozwiązań technologicznych wspomagających zrównoważony rozwój gospodarki. Za kluczowe uznano typowanie i korelację przyszłościowych kierunków badań oraz tworzenie strategii działania na poziomie mikro i makro. Zaproponowano rządowe programy strategiczne jako skuteczną formułę realizacji badań w wytyczonych dziedzinach. Wskazano na potrzebę uwzględniania w programach strategicznych, obok zagadnień dotyczących rozwoju innowacyjnych rozwiązań produktowych i procesowych, działań ukierunkowanych na zapewnienie wsparcia systemowego umożliwiającego transfer opracowanych rozwiązań do gospodarki. Zaprezentowano przykład efektywnego powiązania tego typu zagadnień w realizowanym programie strategicznym.