

Technology Transfer Barriers in Strategic Research Programmes

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Abstract—Research and development carried out within strategic research programmes is an important source of innovations. However, the processes of technology development and transfer into the economy are affected by numerous barriers. The main objective of this paper is to identify and analyse barriers related to the realisation of strategic programmes by R&D organisations. Furthermore, it is aimed at comparative analyses of barriers encountered in the process of executing strategic research in technologically advanced countries and in Poland – one of the transition economies. As a result, the authors discuss: (1) the levels at which the barriers are present (strategic, tactical), (2) their character (technical, organisational-economic, and system barriers to technology transfer), and (3) types of organisational capabilities (physical and material, financial, human resource, information and management) to which the barriers identified relate.

Keywords—technology transfer barriers; R&D organisation; strategic research programmes

I. INTRODUCTION

Technology transfer is a term applied to a very wide gamut of actions taken for the purpose of effective transfer of innovative solutions from the space where they are generated to the area of their implementation and economic or social applications [1, 2, 3]. Studies of technology transfer, which are focused on the social aspect of innovation diffusion, were pioneered as early as the end of the 19th century by the French sociologist Gabriel Tarde, who analysed why only some selected innovations attract public interest and are applied in practice [4]. Interest in this subject matter grew in line with the dynamic development of technology and knowledge society and growing interest in innovation management [5, 6, 7], including specific conditions of carrying out innovation processes in different types of economic entities (big companies, SMEs, start-ups) [8, 9]. This has led to technology transfer becoming an object of in-depth analyses aimed at economic, political, scientific, and organisational aspects of the process [1, 2, 10]. Effective technology transfer encounters a number of barriers to the efficient implementation of innovations to economic applications. These barriers are understood as any kind of limitations that hamper effective functioning of a technology transfer system, and, as a result, disturb co-operation of R&D organisations with enterprises in the implementation and commercialisation processes [3].

The scholars propose different classifications of barriers with regard to the following criteria: the character of a barrier [1, 11-14] or the barriers' driving power and dependence power [15]. The paper's authors apply their own classification of barriers [16, 17], taking into account the following criteria (Fig. 1):

- The character of barriers, comprising (1) technical barriers, (2) organisational-economic barriers, and (3) system barriers to technology transfer;
- The connection of barriers with types of organisational capabilities (physical and material, financial, human resource, information and management); and,
- Levels at which barriers occur: strategic, tactical, and operational.

The results of the state-of-the-art review focus on barriers observable at the strategic and tactical levels. At the strategic level, system and organisational-economic types of technology transfer barriers are observed. The most significant are barriers relating to the absence of effective mechanisms to support the commercialisation of research results and excessive bureaucratisation connected with programmes execution [18-22]. At the tactical level, all three types of technology transfer barriers are observed, namely system, organisational-economic, and technical ones. Different expectations, needs, and the ways of functioning of science and business entities, whose effective collaboration is a pre-requisite to realisation of strategic programmes according to the objectives and implementation of their results, are the key barriers [18, 19, 22, 23-27].

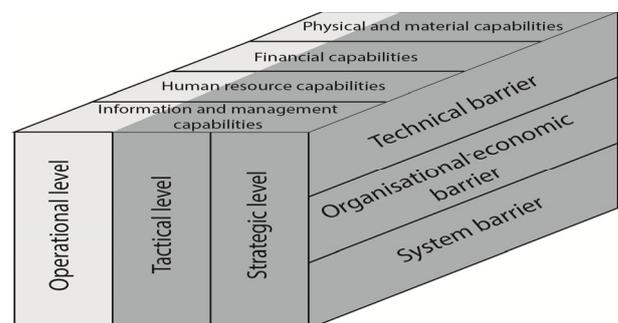


Fig. 1. Authors' classification of technology transfer barriers (The barriers addressed by this article are shaded grey), (Source: The authors).

This paper aims at identifying and analysing technology transfer barriers concerning technologies developed and implemented as part of strategic programmes. This objective arises from key significance of this type of programmes to the development and application of innovations at national, regional, or sectorial levels.

The authors have investigated if technology transfer barriers encountered in the course of executing strategic research programmes in technologically developed countries are consistent with those met in Poland.

II. METHOD

The authors have identified and analysed the barriers in already executed strategic research programmes in different countries and in Poland. The analysis is conducted on the basis of the evaluation reports prepared after the completion of the strategic research programmes.

The following methods are used in order to achieve the results:

- Case study analysis of the strategic research programmes in different developed countries,
- Case studies of Polish strategic programmes in which the participation of the paper's authors is apparent, and
- Comparative analysis of the identified barriers.

Strategic research programmes for case study analysis are selected taking into account the following criteria:

- Specificity of the programme – the subject area comprising advanced technologies contributing to sustainable development,
- Technologically advanced countries according to the Global Innovation Index [28],
- The execution of the programme at the national level,
- High budget devoted for the programme execution, and
- Geographic diversity.

The case studies are analysed with regard to the barriers as follows:

- Observed at the strategic and tactical levels;
- System, organisational-economic, and technical barriers;
- Barriers related to any type of organisational capabilities: physical and material, financial, human resource, information and management.

The result of the comparative analysis gives an answer to the question about the similarities and differences of barriers observed in the course of executing strategic research programmes in technologically developed countries and in Poland.

III. RESULTS

Taking into account the aforementioned criteria, the strategic research programmes in Japan, Canada, Finland,

United Kingdom, Switzerland, Australia, and Denmark have been selected. At the strategic level, system and organisational-economic barriers are observed. At this level, the most important system barriers comprise the existing, changing, or absence of legal regulations [29], the low practical utility of results, or the low awareness of their importance [30, 31]. The majority of barriers at the strategic level are related to the capabilities concerning information and management. With regard to organisational-economic barriers, the most important ones concern problems of cooperation with different entities, both at regional and national levels [32, 33, 34]. These barriers are also mainly related to information and management, but some are connected with financial and human resource capabilities. At the tactical level, the number of system barriers observed is limited, and they concern focusing of strategic programmes on basic not on applied research [34]. At the tactical level, the most numerous barriers are those of an organisational-economic character. Some of them relate to competences of staff [35] or the involvement of a particular group of employees, e.g., women researchers [34], other concern cooperation with companies [32, 35] and end-users [30]. In a very limited number of cases, resource misallocation is mentioned [30]. The majority of barriers at the tactical level are related to human resource and information and management capabilities. In the analysed case studies, a technical barrier identified concern the fact that the programme results achieved are too innovative for the industry [29].

Strategic research programmes of key significance to the development of the national economy have been conducted with leading expert and organisational participation of the authors at the Institute for Sustainable Technologies - National Research Institute in Radom (at present Łukasiewicz Research Network – Institute for Sustainable Technologies), Poland. A Multi-Year Programme PW-004 'Development of Innovative Systems of Manufacturing and Maintenance 2004-2008' and a Strategic Programme 'Innovative Systems of Technical Support for Sustainable Development of Economy', 2010-2015, need to be mentioned in this connection as they have brought considerable cognitive and application outcomes generating several hundred solutions applied in the economy.

The authors present barriers encountered in the realisation of these strategic programmes and the implementation of their results at the strategic (Table I) and tactical (Table II) levels.

In the course of executing strategic research programmes by the paper's authors, system and organisational-economic barriers are observed at the strategic level. The most important ones comprise a lack of a systemic approach to continuing or generating new strategic programmes constituting the logical and technical consequences of previous ones. Among organisational-economic barriers, attention is paid mainly to the need of adapting the way the programme is executed to the changing environment conditions and formal requirements. Barriers at the strategic level relate to all indicated types of organisational capabilities: financial, physical and material, human resource and organisation and management. At the tactical level, the most numerous barriers concern those of an organisational-economic character. A limited number of system and technical barriers are also indicated. Organisational-economic barriers also include problems of

effective programme coordination due to numerous partners and differentiated research subjects. Again, the observed barriers are related to all types of organisational capabilities.

IV. DISCUSSION

While conducting strategic research programmes, the authors encounter barriers to their realisation that match those experienced in technologically developed countries, e.g., at the strategic level – the lack or improper regulations or policies. At the tactical level, they concern problems with cooperation with various entities.

TABLE I. BARRIERS TO THE REALISATION AND IMPLEMENTATION OF STRATEGIC PROGRAMME RESULTS NOTED AT THE STRATEGIC LEVEL (SOURCE: THE AUTHORS).

Type of barrier	Reference to the type of capabilities
System barriers	
No systemic continuation of a strategic programme resulting in a high likelihood of project renewal in dispersed structures and another financing of research and development that have already been carried out.	Financial Information and management
Systemic generation of directions of future research (e.g., using foresight) which is not reflected in the programming of continued strategic projects	Financial Human Information and management
State or regional policies that do not match the potential available or capable of being acquired within a period conditioning launch of an innovative product	Physical and material Human Information and management
Organisational-economic barriers	
Need to adapt financial aspect of a programme to law that is changeable over time, e.g., tax changes that restrict a project's budget	Financial Information and management
Neglecting the development of organisational capabilities for future applications of innovative solutions and laboratory facilities with regard to the most promising directions of research, considering the structure of contractors and national and regional policies	Physical and material Human Information and management
Organisational solutions conditioning programme award that promote totally unreasonable realisation assumptions, e.g., the allocation of research resources only to industrial entities	Information and management

TABLE II. BARRIERS TO THE REALISATION AND IMPLEMENTATION OF STRATEGIC PROGRAMME RESULTS OBSERVED AT THE TACTICAL LEVEL (SOURCE: THE AUTHORS).

Type of barrier	Reference to the type of capabilities
System barriers	
Restrictive requirement to meet economic and material indicators assumed for a long time-frame where technical, operational, and environmental conditions of programme realisation change in the usually long period of the its accomplishment	Information and management
Organisational-economic barriers	
Hard to coordinate a number of executive entities from different areas of knowledge, organisational structures, methods of financing, geographical locations, etc.	Human Information and management
Time delays due to a formal, multi-level structure of project management	Information and management
The need for integrated supervision of many projects on a variety of subjects and ongoing monitoring of their progress (estimation of implementation readiness)	Information and management
Setting current technological solutions against plans made several years earlier and the need to keep modifying them due to administrative difficulties (evaluation of innovative potential)	Physical and material Human Information and management
Technical barriers	
Collision in execution of model and prototype solutions caused by the need to materialise R&D results piling up in a short period (design, production, control and IT systems); time priorities, cooperation of various executive structures	Physical and material Human Information and management

A common barrier also comprises the practical use of products developed within the strategic programmes. The dissemination of programme results is of key importance at the strategic level. Barriers in this area have been observed both in technologically developed countries and in Poland. One of methods facilitating the dissemination of new technologies to numerous business entities could be standardisation [36]. On the other hand, a new paradigm of product personalisation can be applied [37]. In case of R&D organisations, both paradigms are applied. Generally speaking, standardisation is frequently used in the case of cooperating with large companies with mass production. Personalisation is mostly used in the case of SMEs and start-ups. However, personalisation (in the paper referring to design of special prototypes and unique equipment) or more often mass customisation is also applied in the case of large companies if they need unique solutions oriented to mass clients but with individual demands.

Apart from technology transfer barriers, the authors also identify additional barriers, not mentioned in the analysed case studies that are common for technologically developed countries and for Poland. They are primarily observed at the strategic level and include the lack of a systemic approach to the continued pursuit of research subject matter as part of subsequent strategic programmes or research projects and a mismatch between organisational capabilities and research directions generated at the national or regional levels. The difference at the tactical level comprises mainly the issue of the time distance between setting the goals of the programmes and planning technologies for the development which is usually some years before starting the programme execution. It causes difficulties in Poland, where there is not enough flexibility in changing the scope of the programme, when it is already approved for execution by the funding body. It would be advisable to widen the scope of case studies analysis and include additional strategic programmes to investigate if the additional barriers met in Poland are also observed in other countries.

V. CONCLUSION

Realisation of strategic programmes, which is extremely important for the development of innovative economies, is key to assuring dynamic development of innovation policy and its stabilisation with regard to research in areas important for a country, region, or sector. However, conducting programmes of this type and implementing their results come up against a number of barriers. The carried out comparative analysis shows some similarities of barriers observed both in technologically advanced countries and in Poland as one of the transition economies. In the case of Poland, some additional barriers are indicated.

Application of a stable and far-reaching scientific and economic policy on the scale of a country, region, or corporation, conditioned by scientific and technological capabilities, economic opportunities, and a vision of future research and application areas is key to the elimination of barriers at the strategic level. At the tactical level, appropriate matching and the use of all types of organisational capabilities suitable to the subject matter and the scope of conducted research and development, play an important role and significantly contribute to the effective execution of strategic research programmes.

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