УДК 001.8:330.341.1

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Analysis of Practical Aspects in Implementing Basic Research Projects: International Experience, Ukrainian Realities and Prospects

Peculiar features in implementing basic research projects as part of the innovation system and effective ways of strengthening the practical focus of basic research projects in Ukraine are studied. Peculiarities of basic research projects management are highlighted in light of theoretical aspects and global experiences in building up innovation systems. It is emphasized that a serious problem in basic research projects management is choice of effective forms of their financing. Main problems related with market promotion of basic research results in Ukraine are analyzed. Recommendations on development of innovation system and basic research in Ukraine through engaging domestic researchers in the global innovation system and the European Research Area are given.

Keywords: *basic research, research and development, technology, innovation, research area, national innovation system.*

Increasing of the innovation activity in Ukraine requires consistent transition from linear innovation model to marketing innovation cycle model, resulting in the necessity for implementing new organizational and economic methods of fundamental projects management.

Today the companies in developed innovative economies, in contrast to the period of industrialization, monitor the emerging new scientific knowledge as early as at the phase of fundamental research, and seek for capitalizing from the positive results once they are generated. As a result of such competition, scientific and technological progress has gradually transformed into a scientific and technological race.

Labor intensity of the advanced basic research, necessity of purchasing modern equipment and materials, a wide range of project executors due to cooperation and interdisciplinary nature of projects entails the multiplicity of sources for financial support of basic research, which include both budgetary and extra budgetary resources. The limitations of these funds set the task of optimization, based primarily on practical orientation of projects.

Generally, basic research is theoretical and (or) experimental research aimed at generating new knowledge about the basic laws of nature, human and society, human-made objects. Today, basic research should be practically oriented i. e. aimed at solutions for scientific problems related to practical applications.

This being born in mind, the aim of the article is to analyze peculiarities of implementation of basic research projects in the innovation system and consider advanced methods for improving practical orientation of these projects in Ukraine.

Over the past decade, basic research in Ukraine has undergone significant changes. Some research areas were not demanded in the global R&D market, whereas others had to be created anew. In a way, reorientation of research in Ukraine is being on now. The problems of Ukrainian research are very important not only from point of the contribution to global scientific knowledge, but also in terms of practical implementation.

Practical use of research achievements is a primary task and problem for the Ukrainian R&D. Today, in the period of rapid R&D growth, results of the latest research have implications for all the walks of social life in each country. This radically changes the social status and the role of R&D, its value being increased manifold and its organization becoming very complicated, its applications being put in focus of national policies.

Science and technology studies have long been conducted by the so-called linear model of innovation. In this model, basic research is located at the beginning of the causal chain that ends with productivity growth. Basic research generates theories and discoveries that are redefined in applied research, tested thereafter in technological development and, finally, brought to the market as industrial innovation. Each level in the linear model produces a result that is passed as input to the next level. Knowledge flow is straightforward, meaning that a later phase does not provide inputs to earlier phases [1].

The model implies that scopes and limits of basic research have significant implications for the technological innovation. Research component has several factors.

The first factor is that basic research lays the ground for the emergence of ideas that lead to the emergence of innovation. Basic research is an engine of innovation, and research centers should ensure that this engine operates [2].

As the research areas expand, the problem of advanced research facilities and methods becomes increasingly acute. Experience shows that without modern equipment that would allow for most accurate measurements research cannot produce the results needed for country's development. Also, the effectiveness of research strongly depends on the research methodology. The above raises an important problem of methods for practical implementation of research results in Ukraine.

Radical change in research has caused reorientation of research areas. While previously basic research was supposed to be converted into applied research and technological development and be marketed afterwards, now, with the changing innovation cycle, basic research can be immediately converted into a market product. This is particularly evident in high-tech areas such as biotechnology, nanoelectronics, synthetic biology and others. However, in Ukraine, with absence of the necessary R&D facilities and the demand for R&D results, there is a problem of lack of support for subsequent implementation of fundamental research.

It follows from the above mentioned that customer demand can be increased by selecting potentially demanded research areas at the phase of basic research. The selected themes must be of immediate importance. This requirement is one of the key. For many research areas where basic research has been highly developed, the issue of the efficiency of research subjects is not very complicated.

When selecting research themes, methodological and technological capacities of research should also be considered. Today, research in developed countries is dominated by electronics, computers and telecommunications equipment, software, robotics, biomedical engineering etc. In Ukraine, where the share of high tech products in the exports has been shrinking, and the share of exports with low value added is 95%, basic research in advanced fields have nevertheless continued [3].

One of such advanced areas is film materials science in micro- and nanoelectronics. Development of microelectronics and nanoelectronics requires search for new film materials with preset characteristics for creating components that would have a wider range of functional properties. Basic and applied research of film materials for their further use as sensitive elements of various sensors will allow for creating elements of micro- or nanoelectronics, which will be more cost-effective due to their low cost and high quality of final product. However, a number of problems occur at subsequent phases. Outdated materials and facilities cannot meet the current requirements, which results in lack of customer demand.

The second factor is the availability of capacities for strategic interdisciplinary research in priority science and technology fields.

An important issue is the disciplinary distribution of Ukrainian R&D. Today, glo-

bal economic competitiveness is based on multidisciplinary research. The solution to this problem could be creation of multidisciplinary institutions in Ukrainian academies and universities.

Another important step is R&D commercialization. Entrepreneurial function of R&D makes researchers engaged in it through technology transfer. However, because R&D in Ukraine is at the transformation phase, there's nobody to generate new high-tech sectors and new niches of research: Ukraine lacks highly qualified researchers.

The third factor is that basic research should be applied to specific market opportunities, to have a commercial effect. It involves use of innovation grants to support applied research, and studies on management of innovation and entrepreneurship.

In advanced models of innovation management, the key problem is in selecting more effective forms of financing, which would allow for taking into account results of basic research and relating them to the costs, in order to assess the effectiveness of expenditures on basic research.

An important issue in the context of the national innovation system of Ukraine is setting up the ratio of budget and off-budget sources of financing, with determining the possibilities and the propriety of attracting off-budget sources for financing of some basic research projects and the scopes and mechanisms of budgetary support for basic research.

The objective of basic research is discovering theories or hypotheses and methods of their possible applications, which, apart from purely scientific importance, have the potential consumer value.

Basic research cannot be immediately commercialized, because it does not feature customer utility. This is the most important point. The second point is the low probability of producing expected results (from 5 to 10%), which causes a very high risk of losses for customers. Third, results of basic research are very difficult to price, as their recognition occurs only after their discussion in scientific circles.

As a result of the above circumstances, basic research today is financed mainly from the budget. The share of basic research performed in Ukraine by contracts from domestic customers is about 1%, whereas in countries with developed market economies such as the U. S. or Japan it is about 4.5%. Once the innovative marketing model cycle is introduced in Ukraine in place of the linear model of innovation, the share of basic research performed at customer expense is expected to increase to 1–2%.

The Japan's national innovation system was established in 1960s, and at that time they had no access to global basic research, but they realized that they needed to create their own. Immediately after II world war, they did not have the money for it, and they were sending their students to study abroad. This means that a costlier part of the innovation process, referred to as basic research, they left to do for countries that were winners in II world war, but They were bringing home ready innovative ideas and creating innovative products at home. This changed the situation dramatically. While in 1960s the U. S. controlled 98% of the global semiconductor market, due to the national innovation system of Japan and the active intervention of the Japanese Ministry of Industry in 1970s, all American companies were closed and the market was entirely under the control of the Japanese.

Generally, East Asian model of innovation management, which can be useful for Ukraine, can be described as a model of innovation-driven development, where there is no phase of formation of fundamental ideas. Research laboratories at corporations have important role in this model as the location of core technological development. However, a component of basic research is of minor significance in this model, which can be explained by orientation of East Asian countries on adaptation of technologies and high tech exports. Suffice it to recall the paradigm of "flying geese", proposed by K. Akamatsu. The meaning of the model is that many capital-intensive industries have evolved due to know-how and advanced technologies transfers, transfers, transfers, triggered by foreign direct investment [4].

Because a technology may be replaced a by next-generation technology, operat-

ing on another fundamental principle, its improvement does not make sense in the long run. In view of this, modernization projects, improvement of technological solutions are not "breakthrough" ones. The latter include projects of the next technological tenor. As implementation of such projects is much more complicated and is associated with fundamental changes in the industry, it requires a different level of competence.

Emphasis should be made on linking the fundamental scientific principle (scientific discovery) and the technological solutions based on it, which is a fundamentally new technology that is introduced into practice. This link is central to a system that we refer to as industry, cluster or infrastructure.

When in Ukraine engineering sciences are classified as applied ones, this classification is based on the traditional borderline between "pure" and applied research. While the purpose of "pure" research is "to know", the purposes of applied research is "to do". Applied research is, therefore, considered only as applications of basic research that discovers the laws of nature. However, this approach does not allow for determining the specifics of technical sciences, as both natural and technical sciences can be considered both in terms of generating new knowledge and applications of this knowledge for specific purposes, including technical ones. In addition, the natural sciences can be considered as applications for mathematics. In other words, break down of sciences by practical application criterion cannot be strict.

Each project involves radical change in the fundamental scientific principle, as more often it has one or two directions. In addition, the issue of changing core technologies can be involved.

The effect of basic research implementation is calculated as multiphase, rising income from sales of the products manufactured on the basis of brand new materials developed, i. e. the results of basic research. An example of a phased implementation scheme for high technologies can be practical application of nanotechnologies.

The implementation scheme can be summed up as follows [5]:

1) basic research of methods of measurement, processing and modeling of the behavior of matter at the atomic and molecular level;

2) development of new heat-resistant and durable materials;

3) their applications in the following sectors:

a) information technologies, for development of storage devices based on respective semiconductors;

b) biology and medicine, for manufacturing of biosensors providing "targeted drug delivery";

c) energy and ecology sectors, for use of solar energy, production of fuel cells and environmentally friendly materials etc.

For example, innovative developments in nanoelectronics cannot be effectively introduced mainly due to lack of innovative SMEs, which cannot be created in the hard economic situation in Ukraine. The domestic business is focused on trade in natural resources, because investment in long-term projects with the expected returns in 5 to 10 years is too risky in this economic situation. Invitation of foreign investors who could finance innovative projects and help move from basic to applied research, followed by introduction of a product to the market, is also almost impossible due to the unstable economic situation and mass-scale corruption.

It is clear that given the current situation at the domestic market of investments in innovative research projects, R&D results will be confined to the phase of basic research.

We believe that of the tools that can ensure implementation of the marketing model, emphasis should be made on the innovation network that represents an optimal hybrid form and has an intermediate position between market and hierarchy, and that is a new phase of innovation development models [6]. Based on the conclusion that the international innovation networks are a new tool, we propose the following sequence of their development on the basis of the innovation cycle:

1) research networks that are focused on basic research;

2) research networks that combine both basic and applied research;

3) technology transfer networks as a set of partnerships between academic and industrial organizations, providing rapid commercialization of research results;

4) scientific and production networks as a set of partners from research, education and industry, which are integrated by a common goal: to support all phases of the innovation cycle;

5) strategic networks, a kind of scientific and production networks, where additional development is a long-term strategy for all participants on the basis of their relationship.

We believe that the way out of this situation could be participation of Ukrainian researchers in European programs of development and innovation, such as "Horizon – 2020". The Presidential Law on the ratification of Agreement between Ukraine and EU on the Ukraine's participation in EU program "Horizon – 2020" (2014–2020) was approved by the Ukrainian Parliament in 2015. The purpose of this program is in promoting economic development based on the link between research and innovation and transfer of scientific ideas from laboratories to the market [7].

Associate membership means use of all the financial capacities of the program, development of project proposals, building up research consortia and funding.

Ukraine's participation in "Horizon – 2020" will expand significantly the involvement of Ukrainian researchers, universities, research institutions in collaborative European research and lay the grounds for structural reforms in the Ukrainian R&D and innovation. The already mentioned principle "transfer ideas from the laboratory to the market" will have a positive impact not only on the domestic R&D but also on the domestic industry and economy through opening up the opportunities for development of high-tech industries.

The quality of education and research cannot be enhanced without internationalization. International cooperation at the level of universities, research institutes and individual researchers is an essential requirement for the full integration of Ukraine into the global innovation area.

"Horizon – 2020" program is based on the principles of public tenders that are announced by the European Commission in a particular research field. Most part of contests requires submission of a team project proposal. The program involves partnership approach and encourages formation of teams from different countries.

It should be clearly understood that the "Horizon – 2020", despite its huge budget, is a highly competitive program that requires skills, abilities and novel ideas from grant applicants. Advanced trends in research and operation of innovation market need to be understood. Yet, the out-dated domestic R&D facilities prevent Ukrainian researchers from becoming equal members of consortiums, entitled for fair compensation for their work.

Networks provide such benefits for research institutions: possibility to promote their own innovative technologies and find appropriate partners, opportunity to identify industrial partners to transfer their innovation, support during the whole process.

Enterprise Europe Network (EEN), as the largest European network for business support, offers various kinds of assistance. The nomenclature of services provided by EEN network includes [8]:

- provision with practical information on market opportunities, European legislation, assisting entrepreneurs in finding business partners using its own database of business and technological cooperation, providing information on tender opportunities and international cooperation;

- development of research and innovation competencies of enterprises by supporting the creation of synergies with researchers and research institutions, promotion of technological cooperation and organization of various networking events (forums, platforms, conferences, seminars, etc.);

- support in disseminating results of research and development, in participation in research programs and obtaining funds.

It can be concluded that building up the integrated R&D and innovation area, with the established links between various sectors of R&D and economy, will enable for bringing together R&D and business and contributing in practical use of the results of basic and applied research.

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Одержано 28.09.2015

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Аналіз практичних аспектів реалізації фундаментальних наукових проектів: міжнародний досвід, реалії та перспективи України

Досліджено особливості реалізації фундаментальних наукових проектів в рамках інноваційної системи, а також перспективні шляхи підвищення рівня практичної спрямованості фундаментальних наукових проектів в Україні. У рамках аналізу теоретичних аспектів та світового досвіду розвитку інноваційних систем розглянуто особливості менеджменту фундаментальних наукових проектів. Показано, що значною проблемою менеджменту фундаментальних наукових проектів є вибір ефективних форм їх фінансування. Проаналізовано основні проблеми, пов'язані з просуванням на ринок результатів фундаментальних досліджень в Україні. Надано рекомендації щодо розвитку інноваційної системи та фундаментальної науки в Україні на основі залучення вітчизняних вчених до глобальної інноваційної системи та європейського інноваційного простору.

Ключові слова: *фундаментальні дослідження, науково-технологічна система, технології, напрямок досліджень, інновації, національна інноваційна система.*

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Анализ практических аспектов реализации фундаментальных научных проектов: международный опыт, реалии и перспективы Украины

Исследованы особенности реализации фундаментальных научных проектов в рамках инновационной системы, а также перспективные пути повышения уровня практической направленности фундаментальных научных проектов в Украине. В рамках анализа теоретических аспектов и мирового опыта развития инновационных систем рассмотрены особенности менеджмента фундаментальных научных проектов. Показано, что значительной проблемой менеджмента фундаментальных научных проектов является выбор эффективных форм их финансирования. Проанализированы основные проблемы, связанные с продвижением на рынок результатов фундаментальных исследований в Украине. Представлены рекомендации по развитию инновационной системы и фундаментальной науки в Украине на основе вовлечения отечественных ученых глобальную инновационную систему и европейское научное пространство.

Ключевые слова: *фундаментальные исследования, научно-технологическая система, технологии, инновации, направление исследований, национальная инновационная система.*