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Managing the transformation of R&D results into practical applications:
The case of a country in transition

Key words:
technological innovation, innovation process, transformation process

Abstract

The paper refers to technological innovations as practical applications of R&D projects. The main aim of this paper is to formulate key issues in the management of the transformation process of R&D results into practical applications. A special emphasis will be put on identification of key conditions for success in this process. Poland, being a country in transition, will here be a case-study. The paper is based on the outcomes of a research project "Methods of transforming R&D results into practical applications in Poland", headed by the author within a research programme coordinated by Institute for Exploitation Technologies in Radom, Poland.

Introduction

Traditionally, research and development (R&D) as a crucial component of the innovation process was performed outside of enterprises – in universities and other higher education institutions (HEIs) and in independent (public or private) research institutions. This model was known as the science-push process of innovation. Nowadays, it is very difficult to answer the question: Where is R&D performed presently? And how? The Triple Helix (spiral) model of innovation may prompt an answer. But not only. Various innovation models exist now in practice, like: interactive, integrated and simultaneous models (Rothwell, 1992).

Now, research being an element of the innovation process may also be performed in other forms or ways. The following recent models of innovation are widely known:

- open innovation, mainly via Internet,
- user-driven innovation which is a kind of re-make of a demand-pull model, and
- globalized process of innovation – within trans-national corporations (TNCs).

However, we can still witness traditional, linear processes of innovation, like those mentioned above, i.e., the science-push and demand-pull models. Poland as a country in

transition or transitional economy is also such an example. The national system of innovation in Poland has three key weaknesses (Jasinski, 2006a) which are relics of the past[1]:

* a very small R&D potential *within* enterprises; less than one tenth (9% in 2008) of all R&D workers in Poland are employed in firms and similar economic entities,

* most of R&D (69% in 2008) is performed outside the business sector, and

* over half (56.1% in 2008) of financial sources for R&D comes from the state budget.

So, in the situation when R&D is being performed or located mainly in the science sector while innovation is being implemented mainly in industry/enterprises, an issue of science-industry linkages or co-operation is of crucial importance. Thanks to such linkages, a transformation of research results into practical applications should occur. Therefore, in the case of Poland, the quick, broad and successful transformations of new knowledge created within the sphere of public research into industrial innovations are extremely important for improving the country's low level of innovativeness.

Let us add that in 2006-2008, only 14.6% of Polish small manufacturing firms (up to 50 employees) introduced technological innovations while 60.7% of big companies (over 250 workers) introduced such innovations in this period, i.e., over four times more (GUS, 2010a). This means how crucial this issue is in the case of smaller firms.

What is the process of transforming R&D results into practical applications?

When a research project is completed, a transformation of its results often begins which should lead to a technical innovation. The essence of the transformation process is the implementation and commercialization of research outcomes. Of course, the process is not always successful.

A subject of analysis here is a set of processes making up – as a whole – an innovation process. These partial processes are as follows: research, transformation of its results into practical applications and accompanying processes of technology transfer (TT) and diffusion of technological innovation. These are, to some extent, the stages or phases of the whole innovation process.

According to Pavitt *et al* (1999), the innovation process consists of the following phases:

[1] All statistical data come from GUS (2010b). GUS is The Central Statistical Office in Warsaw, Poland.

1. *Scanning* the business environment for, and processing relevant signals about, threats and opportunities for change;
2. *Deciding* which of these signals to respond to;
3. *Obtaining* the resources to enable the response;
4. *Implementing* the project to respond effectively; and
5. (optionally) *Learning* from progressing through this cycle.

The key element is Stage 4, which is the core of the innovation process and which usually represents the organizational form of an innovation project. This phase may be conventionally divided into two sub-phases:

(a) a research and development process, and

(b) a transformation process of R&D results into practical applications.

The latter determines whether an innovation will appear or not.

Let us note that sub-phase (a) can occur in a company, if it possesses own research facilities (Case 1) or outside a company, e.g., in a university or an independent R&D laboratory (Case 2), while the sub-phase (b) usually takes place in a given enterprise. In Poland, for example, a more frequent is *Case 2*. So, this case will further be taken into consideration.

The process of transforming research results starts following the completion of R&D work, e.g., in a form of prototype or a pilot manufacturing installation. Considering an issue of commercialization, a research project result should make a concrete offer for industry.

The transformation comes to an end in the moment when the production and commercialization of a new product begins (a product innovation) or production installation based on a new technology starts (a process innovation)[2]. In the case of a new product, this is the moment when its product life cycle begins.

The transformation of research results to practice is nothing other than a symptom of a vertical technology transfer (new knowledge flows) from a research institution to an enterprise or, broadly, to industry. Often occurring afterwards, a horizontal transfer of knowledge between firms begins with a diffusion of innovation. An issue of TT leading to the transformation of R&D outcomes into practical applications is extremely important in the case of small and medium-sized enterprises (SMEs) which usually do not have their own in-house R&D facilities.

[2] According to Freeman (1982), innovation is a first commercial introduction of a new product or process.

On the basis of this, the whole set of processes can be presented comprehensively in the form of a chain as illustrated below:

Initiation → Research → Transfer → Transformation → Diffusion

A starting point here is a research initiation which, *nota bene*, can come form various sources, like: enterprises, universities, R&D organizations, public institutions, etc. Afterwards, research and development is performed. Its result is a new knowledge in a form of scientific and technological (S&T) solutions (products or processes). Then (in Case 2), this knowledge is usually transferred from research institutes to various economic entities where its implementation and commercialization take place. This is exactly the transformation of R&D results into practical applications, i.e., technological innovations. Finally, their diffusion should be treated as a natural, desired completion of the innovation process (Jasinski, 1992).

It must be added in this place that, in Poland, processes of innovation diffusion have been very weak and narrow for many decades. Moreover, the diffusion processes in the national economy have been also poorly investigated by researchers.

Let us take an example where R&D had been performed in a company (Case 1) which implemented and commercialized its findings, then TT doesn't take place. According to Premus (2002), technology transfer occurs when a technology crosses the boundary from one organization to another organization. This usually refers to SMEs where a new S&T knowledge must overcome the organizational boundry.

Innovation 'stands on two pillars': one pillar still lies in R&D, with the second in Production. Thus, a permeable transfer between the two spheres is important here. In advanced market economies, good (meaning wide and intensive) co-operation between the R&D sector and industry creates favourable conditions for technology transfer from science to the business sector and for TT among industrial enterprises also.

The transition process from various points of view

The process of transforming R&D into innovation can't be taken out of context and then it should be treated as a component of the whole innovation project. However, the transformation process itself consists of several elements, so must be suitably structured. There is no universal depiction of this process because it can be considered from various points of view (Jasinski, ed, 2011).

For an engineer – it will be a set of production and technological operations which should result in manufacturing and selling of a finished product. The process can conventionally be divided into four stages:

1. *Maturation:* results of R&D should be completed in detail and lead to a form suitable for implementation[3];
2. *Real investment:* usually new physical assets are necessary to innovate;
3. *Implementation* ending with a start of production;
4. *Commercialization:* a new product appears in the market.

For a manager: it will be a decision-making process containing investment, production, marketing, financial and similar decisions. Thus, the transformation process is subject to management. Simplifying, the flow of R&D results to the practice – as a decision process – can be expressed in the following phases:

1) *preparatory activities* which should start before the project ends; here we mean marketing, co-operation, partnership, etc.,
2) *decision* concerning a form/way of flow, e.g., sales of research result, license, etc.; an issue of intellectual property rights (IPRs) protection should here be considered[4],
3) *decision* on who will deal with an organization of the flow:
    a) 'we on our own' that is the research institution where the scientific and technological solution appeared or
    b) 'foreign hands' that means professionals, for instance, a bridging institution,
4) *conclusion of contracts* with a producer, bank, agent,
5) *assistance* towards an innovating firm in the implementation and commercialization (on the spot) and *control* of these activities,
6) *evaluation* of the whole transformation process, together with the partners.

For an economist: it will be a process generating expenditures (costs) and effects (incomes, profits). In other words, an economist will look at the whole process via the prism of effectiveness. Nevertheless, he/she differently evaluates the earlier stages then the later ones. He/she usually looks at:

- the R&D phase – via the prism of expenditures and
- the commercialization phase – via the prism of economic effects.

[3] Sometimes, additional experimental development work is needed here.
[4] In Poland, an issue of IPRs protection was always neglected.

For a marketer: it will be a chain creating a value for a user/buyer in subsequent phases. In a comprehensive approach, we have three basic stages or rather links in an innovation creation chain:

1. *Initiation and establishment* of a research project – the main addressees of the offer will be R&D institutions;
2. *Research and development* – here an investor or entrepreneur[5] will be the results' user;
3. *Implementation and commercialization* – in this phase, the main users of a new product will be consumers/households or producers-buyers of industrial goods.

It must be added here that, in Poland, marketing experiences in economic entities in the field of R&D and innovation still are very poor.

As seen, each point of view is different and within each of them the number of stages in the transformation process is different too, although some phases are similar. Each one needs to be evaluated in its own right. Generally speaking, all the view-points should make a complex, integrated approach.

Conditions for the transformation process management

For an efficient course of this process, a potential user of R&D results, ie., an entrepreneur (small, medium-sized or big) should:

- become involved in the research process/project as early as possible. This refers to the concept of user-driven innovation,
- co-finance the project,
- have a possibility to get a support from outside, e.g., a public support from a central, regional or local government,
- have a guarantee of decent profits.

As mentioned earlier, the transformation process usually is preceded by a technology transfer. According to Rosenberg (1982), the essence of the modern TT is diffusion of information based on new scientific-technological solutions and the knowledge about their potential applications. In turn, a range and speed of information diffusion depends, to some extent, on organization and functioning of various networks. And so, efficient networking is a basic condition for sufficient flows of a new scientific and technical knowledge. The concept of open innovation here is a good example of networking.

[5] Not always it must be the same person.

An inflow of the new knowledge to an enterprise is the result of an outflow of this knowledge from a research institution. These are like two sides of the same coin. Then, both sides should create conditions favourable for such transfer. However, they often speak different languages and have different expectations and aspirations which result from a dissimilar nature of the science sector and the business sector.

According to our empirical study (Jasinski, 2009), the main barrier for knowledge transfer in Poland lies on the side of the R&D sector. The respondents always make mention of the following two facts:

- weaknesses within the scientific sphere and its output (R&D results), and
- R&D units not being fully open or prepared to co-operate with firms.

Therefore, research institutions should take it upon themselves to transform their R&D results. Thus, marketing research and marketing of research here have a crucial role to play.

Innovation is a result of the innovation process – this statement is greatly obvious. However, we ought to look at innovation as a result of co-operation between participants in the process. A question of innovation is *a matter of implementation*, whereas a question of transfer is *a matter of co-operation* or rather *partnership.* And so, the establishment of a successful partnership is a basic step where:

- both sides must see a joint interest,
- usually a third partner is needed, for example, a bridging institution,
- a bank or another financial investor as a fourth partner is often necessary,
- and taking into account that innovation usually is a local phenomenon which appears in a given territory, it is worth engaging a local government (a fifth partner). In Poland, innovating firms seldom co-operate with local governments/municipalities.

Thus, there may be five members involved in a partnership. For a successful partnership, a co-operation *animator* or, in other words, an *innovation leader* is needed. He/she can be an entrepreneur (the general manager of an existing enterprise) interested in the implementation (Option 1) or the researcher (the manager of a research team) who creates a new product/process (Option 2). The latter means that the scientist will become an innovative entrepreneur. Unfortunately, this option occurs in Poland too rarely. There may be also Option 3 when the entire innovation process takes place in TNC.

Such leader should work out a co-operation programme/plan based on (Jasinski, ed, 2011):

- personal contacts,
- common language/understanding,
- mutual trust,
- perception of joint interests,
- quick, multilateral communication, and
- risk division.

The process of transforming R&D results into practical applications should be treated as a system consisting of many elements and interdependencies between them. Its three sub-systems can be distinguished as below:

(1) operation sub-system,
(2) information sub-system, and
(3) decision sub-system.

All of them are equally important but here we shall deal only with the last one.

As mentioned, management is a decision making. The decisions, being made by the participants in the transformation process, accompany the course of operations and information exchange. The innovation leader, responsible for the functioning of the whole project, should answer at least four questions (4Ws):

(i) *What* decisions will be made within the subsequent phases of the process?
(ii) *When*, that is, depending on the state of affairs?
(iii) *Who* should take them?
(iv) *Which* assessment criteria will be a base for decision making?

Success factors

Summarizing, conditions for success (or failure) in implementation and commercialization emerge even before the research project has been completed. Therefore, various activities must be taken in advance for which the animator/leader should be responsible. The main success factors are as follows (Jasinski, 2006b):

- *to establish* a consortium of members comprising all the partners/sides mentioned above,
- *to predict* obstacles that will surely emerge during the transformation process and make preparations to overcome them,

- *to treat* a research project result as a market product for which a client should be found. So, there is a need for a good marketing containing (a) market research, (b) market segmentation and (c) marketing actions. The idea of a relationship marketing may here be very useful,
- *to recognize* potential clients-buyers of the project results or assume that a new firm (start-up) should be established,
- *to pull* potential users of innovation, especially a strategic client, *into* the co-operation during subsequent phases of the research project – in order to verify results of concrete stages of research, and
- *to take care* of IPRs protection, especially the legal protection of R&D.

This represents a success algorithm in the application of research project results in practice.

Conclusions

There is no universal model of transforming R&D into innovations. This process requires an approach from various standpoints. The process may end in success - or failure – wherein success here should be treated as the successful commercialization of a new scientific and technological solution (a new product or manufacturing process).

Broad and quick inflows of a new S&T knowledge to firms, especially to SMEs, will make the transformation process more efficient.

Among various success factors, one seems most important, and this is *the skillful management* of both the research process/project as well as the transformation process of its results into practical applications.

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