

## **BUILDING A SUSTAINABLE NATIONAL INNOVATION SYSTEM: CASE OF BELARUS**

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### **Abstract**

*Innovation policy nowadays faces new challenges, such as positioning the country in the world economic structure. The paper deals with the issues of **national innovation system building** under such conditions as internationalization of economic links, and ecological and cultural contexts of innovation activity grow in their significance. The specific schemes of interactions within the innovation system should meet the needs of the economy striving to be technologically advanced, should make use of accumulated economic potential and knowledge stock, and be aimed at general coherence of national innovation system.*

*The paper also analyses some recent empirical studies of **technological collaboration relationships**, which arise in transitive economy of Belarus between public research academic institutes, private-owned innovative firms, and industrial enterprises. As a result, some curious mechanisms of self-organisation of interactions between hi-tech innovators in the process of technology transfer are being elucidated.*

### **Introduction**

The challenge of organising an effective **national innovation system (NIS)** implies regarding it as a complex and dynamically changing structure of organisation the innovation activity. **Innovation process** implies a great number of interactions between institutions, organisations with their functions and aims, between individuals, with their original knowledge and their own interests.

Building the NIS, it is necessary to take into account national specifics of the environment, of which the innovation system is going to become a part. The point here is coherence with external systems (economic, social, environmental). Besides, internal stability of the innovation system needs to be pursued (one should not confuse it with the static state of the system; it is rather an ability to change dynamically pursuing the general aim).

**Stability** of a national innovation system implies the maximum adaptability of the system to negative external conditions of development, and the maximum fast reaction of it to current changes. This can only be achieved, if its particular participants and institutions are

provided with a sufficient **variety of opportunities** to interact, to exchange information and necessary resources, thus enabling the functioning of each other.

As far as the innovation process requires inputs from both economic and social spheres, participants strive to realize the interests inherent to both of them. **How** the interests of various decision-makers are being concerted, contributes greatly to the level of self-development, flexibility and intellectually vitality of the innovation system, i.e. the innovation activity should not be only economically effective, but also *socially integrated* and *environmentally 'engrafted'*.

The course of technology transfer between the developed and developing countries (Szpakowski 2000) and the status they have in the world economy structure gives us a clear evidence of consequences of the policy, if it is not system-oriented. For economically less developed countries there appears a threat of turning into technologically 'cut-off' ones, being not able to design advanced environmentally friendly technologies themselves, and having no sufficient funds to buy them abroad.

As a consequence of ignoring these world economy trends, it is quiet possible that the out-of-date heavy industry production is left in the very heart of Europe, for example, in Belarus, 'contributing' to the environment of all the surrounding technologically advanced countries, as far as the country cannot afford expensive maintaining of ecological standards. The only way out is to develop strong and sustainable NIS in transitive countries, adequate to the pro-European innovation strategy, so that the technological base of traditional industries could be constantly modernised.

### **Belarusian Innovation Potential**

Estimating the chances of Belarus for the high rank in the world economic system, one has to consider objectively, whether Belarus is actually capable to deal with science-intensive production, or the hope for this is illusory. The basis of sustainable innovation system in the country is its scientific and research potential.

Belarus has formerly been integrated into the general Soviet scientific and technological framework, ranking high in applied researches in civil industries such as mechanical engineering (29% of all works' costs), electronics (11%), automatics and computer facilities (9%), construction and architecture (8%), chemical technology (7%) (Nehorosheva 1996).

Industry was the basis of the Belarusian economy: its share in the gross domestic product amounted to about 65%. This made Belarus one of the most heavily industrialized countries in the world. Generally, 79% of technologies applied in Belarus, relate to traditional, and 21.0% - to advanced. Of them, 38% have been worked out in Belarus (*Development of*

*Science in Belarus in 2000*. Analytical Report. P.31). About 48% of technologies applied have been introduced before 1985, and 23% - during the last 5 years (Slonimski 2001).

Scientific, technical and innovation policy in Belarus is oriented on building a national innovation system. Management of R&D in Belarus is provided by realization of state scientific and technical programmes - both in fundamental and applied science. Belarus was one of the first of CIS members to work out the legal base and the operating on its base system of managing the state scientific and technical programmes, which is now the major tool for performing the prior directions' R&D activities.

Applied R&D are carried out mostly in a common framework of 1) state scientific and technical programmes (SSTP); 2) innovation projects; 3) branch and regional scientific and technical programmes.

The sources of SSTP financing are 1) the budget funds, 2) own funds of enterprises, 3) funds of state customers, budgets of regions, and borrowed funds. The legal framework for SSTP managing consists of more than 150 papers, worked out for various levels of management, all the participants, stages, and aspects of the innovation process (financing, intellectual property protection, tax, customer, and other preferences, etc.). In general, the system of SSTP is logically built and prospectively-oriented. Yet, the maximum use of its opportunities is expected to be provided by economic situation stabilization in a country with market mechanisms.

**Table 1. The structure of expenditures on R&D by stages of research process, %**

INDICATOR	1999	2000
Current domestic expenses on R&D	100.0	100.0
Fundamental research	14.7	18.9
Applied research	15.1	23.9
Developments	70.2	57.2

Data taken from: *Development of Science in Belarus in 2000*. Analytical Report. 2001: P. 9.

R&D in technical sciences traditionally prevail in Belarus. The tasks of science and technical sphere reforming require to concentrate efforts on performing R&D in prior directions, where the conceptually new knowledge might be obtained, implying the possibility of its practical application.

In general, in 2001, R&D have been carried out by 299 organisations, from which more than a half (50.37 %) belongs to enterprise sector, 30.5 % – to state sector, and 19.13 % to the sector of higher education. The share of the high-tech enterprises in sphere of small business is very low. Only some 1.4% out of 25.5 thousand of small business enterprises are

innovatively focused. Small enterprises are regarded innovative if they present the reports of their R&D activity to the bodies of statistics.

**Table 2. Small innovative entrepreneurship**

INDICATOR	1993	2001
Number of small enterprises	11428	25404
including those carrying out the R&D activity	560	348
as a share of general number of small enterprises	4.9	1.4
Number of workers	205803	291500
at enterprises conducting R&D activities	7544	2782
as a share of all workers employed at small enterprises	3.7	1.0

**Data taken from: Annual Report to the President of the Republic of Belarus about the Current State of Science in Belarus. 2002: P.74.**

The most general integrated indicator of R&D effectiveness is the number of patents received. The major part of innovations is designed in the sphere of chemistry (18%), machine building and metal processing (17%), medicine (13%), agriculture and food industry (12%), electronics (10%), construction (8%).

Applications on patents are submitted by state enterprises and organisations (36%), natural person (30%), higher educational establishments (20%), entrepreneurship (10%).

**Table 3. Indicators of patent activity development, 2001**

Applications on patents for inventions and industrial models, submitted	1208	Patents on inventions, registered	633
From national appliers	988	From national appliers	441
From foreign appliers	220	From foreign appliers	192

**Data taken from: Annual Report to the President of the Republic of Belarus about the Current State of Science in Belarus. 2002: pp. 59-60.**

The other parameters, in their turn, brightly evidence that the earlier accumulated strong scientific and technical potential is constantly wasted. During the last nine years the **number of the scientific staff** has reduced more than twice, and amounts to about 32 thousand people. **Share of expenses on science in gross domestic product** has decreased in comparison with a level of 1990 before the economic reforms in approximately three times and now amounts to 0.8-0.85 % of GDP, which is considerably smaller than an efficient level of 2-3%.

**Institutional infrastructure** necessary for realization of innovation activity in Belarus has roots that are deep enough, and young branches have begun to develop as well. Its structure consists of the organisations that exist long enough (57 higher schools, institutes of the Academy of sciences, branch scientific research institutes), and of recently appeared private and innovation business supporting organisations (7 centres of technologies transfer, 2 technological parks, 9 incubators of technology-intensive business, 61 centres of business support, patent organisations). All centres are incorporated into the national information system, in order to facilitate their interaction.

### Challenges

Nowadays, the directive state system of organising the innovation process does not meet the requirements of globalising economy and information society' development. The essence of the major problem of innovation activity in Belarus with its transformation economy may be briefly defined as "distorted innovation system" with irrelevant institutions and broken and unsustainable linkages between the fundamental sciences, applied research and industry.

So, that the R&D activities are shifted from industry to the sphere of state science is evident to all. This is an evidence of an essential cut-off of research results from their practical application (see Table 4).

**Table 4. Structure of the scientific and technological potential of Belarus on branches, per cent**

INDICATOR	VOLUME OF R&D WORKS PERFORMED		EXPERTS CARRYING OUT R&D ACTIVITY AS BASIC	
	1990	2001	1990	2001
In general	100.0	100.0	100.0	100.0
Including organisations of:				
<b>Industry</b>	<b>59.8</b>	<b>38.8</b>	<b>53.3</b>	<b>39.1</b>
Agriculture	8.8	8.8	6.9	10.7
Construction	6.5	1.8	6.9	1.5
Transport and communication	0.6	1.4	0.7	1.3
Health and safety	1.2	4.5	2.0	5.6
<b>National Academy of Sciences</b>	<b>13.3</b>	<b>20.3</b>	<b>15.3</b>	<b>23.5</b>
Education	7.3	16.6	6.1	9.1
Other brunches	2.5	7.8	8.8	9.2

Data taken from *Annual Report to the President of the Republic of Belarus about the Current State of Science in Belarus. 2002: P.5.*

Formerly, Belarus has specialized in the framework of Soviet Union, on a large scale the relatively high-tech equipment, paying "damping" prices for raw material, details, energy resources. Now, the problem of restructuring the economy is very topical.

System transformations in the innovative activity sphere of Belarus began in the late 80's. Scientific and technical organisations began to be converted into the self-financing form of operation. At branch R&D institutes, and then at the academic research institutes, the scientific and technical cooperative societies and self-financing "centres of scientific and technical creativity of youth" started to operate. Since 1991, the innovative entrepreneurship

in Belarus has had a status of societies with limited liability and joint-stock companies, which are endowed with more independence, on the one hand, and imposed with more responsibilities, on the other hand.

An obligatory condition of an effective innovation process is **linking the scientific and assisting organisations**, which now often operate not concertedly, and the stimulation of their efforts coordination. Even to a greater extent the **crisis of integration of science into the society** is argued to be disastrous for countries' innovative development, intensified by the crisis of public discussion.

The interrelations between the actors of the innovation process are to be built according to the new scheme, new roles are to be learned by the society, but **no one actually knows neither what the roles are, nor what the scheme should be**. To fill in the absent linkages in innovation process chain, is a strategic aim of individuals and institutions, which would bind the separated spheres. The question is, who and what should they be?

It is absolutely clear, that new schemes of interactions within the innovation system should satisfy at least the following conditions. First, they should make use of knowledge and experience accumulated in the previous innovation activity, and should be able to benefit from them.

Second, they should fill in the gaps inherent to transitive economy, adjusting their activity to constantly changing conditions. Innovators have to cope with the uncertainty themselves, and be able to fit their activity into the distorted and broken system.

And, the last but not the least, they should bear in mind the specifics of national economic, social, and even mental characteristics. When choosing proper location for innovative production (on regional, or country level), it would be an omission to underestimate the role of educational and social abilities of people to be involved into the process of technology diffusion, as well as the socio-ecological consequences of introduction of this innovation in specific region.

It may be curious to trace the development of **new scheme of collaborative technological relationships** between research and technology academic and private-owned organisations and industry companies, as it emerges in transitive economy of Belarus. The network of hi-tech private spin-off firms around the public academic research institute in the capital of Belarus, dealing with new materials' design and production, turns into the original **informal** incubator of small innovative business.

### **Where is a gap?**

As an empirical study shows, the experience of setting up the spin-off companies by large public research institutes (LPRIs) proved to fit well into the innovation activity

conditions of a transitive economy. The essence of the new organisation form may be outlined with a following scheme.

Researchers, who have been engaged in the scientific activity at the academic research institute (working out new processes, materials, developing new technologies and equipment), launch their own small innovative firms, benefiting from the monopolistic scientific knowledge gained during their previous work, developed network of contacts in scientific and business area, and proving to link academy science and industry through science-intensive innovations more effectively.

To estimate the contribution of spin-offs to the innovation system, one needs to consider the initial situation, to see, what the gap to be filled in, is like.

Being a public research institute under state jurisdiction, Physical-Technical Institute (PTI) of the National Academy of Sciences of Belarus has experienced for a long time that the scheme of financing its applied research doesn't meet the requirements of industry. The activity of PTI is financed from three sources – basic financing from the state budget, grants allocated for R&D, and contracts with enterprises.

In 2000, for example, PTI was working on the state programme “New materials and ecologically friendly technologies”, financed by the state budget. In its frames, laboratories of the institute get an order to accomplish particular tasks.

Actually, the forms of R&D financing exercised in LPRI, are very indirectly connected with the market estimation of expediency of the investments in the given R&D. This phenomenon has been described in literature in connection with “science-push” model of innovation activity. Accordingly, “market-pull” falls out from the set of incentives to innovate.

In reality, LPRI are too awkward and inflexible to produce innovations that are close to market. Huge overhead expenses (amounting to 150-300% of institute's wage fund) make the products manufactured using the same equipment, far more expensive than the products manufactured by small firms.

That is why performing of tasks on R&D is often charged by the institute's management to the small spin-off firms working on the territory of the PTI. Achieving the results, these spin-offs apply the knowledge gained in their own commercial activity, producing innovations, which are practically claimed and applied in industry, which isn't bad. Innovative technologies and materials are thus designed, developed, and transferred to industry by **the same people**.

So, the attempts to make applied research and developments predominantly a state function may be viewed as “the state failure”, and spin-off innovative firms as a self-developing market mechanism of improving the situation.

Nevertheless, large public research institutes (**LPRIs**) remain to be the dominant source of scientific ideas with a conventionally performed mission of pursuing long-term research goals, science advancement and know-how accumulation in emerging technological areas.

It is therefore reasonable to make use of the strong features of LPRIs and the contribution they can make into the development of national innovation systems.

### **Spin-offs as links filling in the gaps**

LPRIs **may** act as a bridge between universities and industry, but to do this effectively they should **adapt their organisational structures** so as to correspond to real needs of industry. The function of further developing of research results according to some specific needs of technology appliers *is to be* passed to more flexible and dynamic intermediate organisations between science and industry.

LPRIs frequently launch new spin-off companies themselves, “hand them down” the contacts in scientific and production spheres of economy, lease them the manufacture areas on advantageous terms, and in some cases provide start or development capital, either directly or indirectly. Consulting on scientific research issues is not considered to be a paid kind of service, and it actually occurs in the informal communication form between former colleagues, after they have set up their own firms.

**Spin-off companies** represent a new form of innovation activity organisation, which is not established artificially, not dictated, but has, on the contrary, grown itself, meeting the requirements of the economic life. That they **did arise** is the most convincing argument for their **relevance** in current economic conditions. They are finely adjusted to fill in the gaps in the broken innovation system, implement the earned scientific and research potential, before it has lost its value, and employ the accumulated knowledge while the carriers of it are remained.

Spin-offs are mostly high-tech small-sized start-ups founded by researchers, who strive to receive an adequate and well-deserved compensation for the years of creative intellectual activity they have conducted. Establishment of spin-offs is argued to be especially appropriate in the sphere of new technologies introduction, where both risks and potential returns are high (*Building an Innovative Economy in Europe*. 2001).

Beneficial features, which make spin-offs so relevant in the transitive economy, are the combination of inherent to small firms **flexibility** and independence in decision-making, on the one hand, and the **experience** of their founders **in knowledge-intensive activity** gained

during the work in LPRIs, on the other hand. People engaged in this activity do not start it “from zero-point”: neither in technological knowledge, on which their activity is based, nor in collaborative linkages in scientific world and industrial sphere.

Such an “ability to contact” of spin-off is no longer a secondary advantage, but rather a **mode of existence**. Links, needed to make the innovation process effective, require not only business contacts, but sustainable, interactive, mutually beneficial communication, especially between researchers and scientists themselves, and innovators and customers, who possess different knowledge assets (not better/worse, but various).

For innovative firms, collaboration can contribute to reducing the costs and risks of innovation, as well as to extracting value from new scientific and technological knowledge, or getting access to better resources. Formal interactions can provide the major part of success only in economy where the formal structure of organisations is developed enough, where the relations are institutionalized, where the network of institutes is already developed – therefore, formal interactions are far not sufficient in a transitive economy.

The knowledge of spin-offs’ actors thus includes scientific, explicit knowledge (most of the researchers have patents on their developments), and also social, tacit knowledge of building interactions. Actually, this is knowledge of making their activity socially embedded in the transitive, unstable structure of economy.

### **Spin-offs: mode of existence**

Spin-offs operate in two planes. Researchers collaborate with the academic institutes they come from, executing particular tasks in state research programmes and participating in particular projects; and they operate in industry, executing orders on innovative equipment or products of individual customers and enterprises.

The activity of spin-offs is financed by several sources. The major share of financing comes from customers for jobs executed under the contract. It should be noted, that actually the innovators have no separate sources for financing the further research work, and for this aim they have to allocate the funds they have earned under previous contracts.

As an alternative source of financing the R&D the scheme of collaborative projects with customers is used. A recently emerging form of joint financing the R&D is the “**innovation project**”. The scheme is based on financing of the project by halves by project participants (customer enterprises), and raising the other half of funds from the state budget, which is to be returned by the enterprise when the project is fulfilled, innovation is introduced, and production manufactured after introduction of innovation is sold.

Innovators cannot afford to take risks, executing R&D, creating innovative products, and only afterwards looking for customers for the created innovations, because of limited

financial abilities of customers. Most innovations arise, on the contrary, under concrete order. After the technical task is formulated, the intellectual potential is directed on solving the concrete technical issues. If in the meanwhile the new idea of technical development arises, the new variant is proposed to the customer, and this is often the way the innovation comes into being. Thus, the question of linking the applied science with industry gets solved simply enough, as soon as the innovators have no source of surviving other than satisfying the current needs of the industry enterprises.

Researchers still remain to be scientists, inspired by their own curiosity and thirst for further knowledge. They continue working at the research institutes, conducting research there, and applying the knowledge gained to carry out further applied research at their innovative firm. Formally, innovators distinguish between the developments made under state programmes (joint projects with the research institute), and their own developments (or developments of the innovative firm). But in real life, such a division proves to be not only artificial (as far as the knowledge gained still belongs to the PEOPLE rather than ORGANISATIONS). In my opinion, it would be also harmful for the economy of Belarus today to divide these achievements and prohibit the use of innovations created at the institute, by the innovative firms. On the contrary, this form of research results transfer to industry is to be considered a natural mechanism of survival for a transitive economy.

One of the ways spin-off companies use in order to overcome the financial restrictions of their customers, who are often not able to buy the innovative installations, is changing the profile of their activity: from selling the equipment and technologies, to rendering the service of producing by small lots the innovative products (new materials, innovative coverings, etc.) on firm's own installations. This scheme of interactions allows conducting normal economic activity, satisfying the solvent demand of enterprises in innovative products, and not selling the technologies themselves.

### **What do spin-offs lack: heritage of LPRIs**

Having examined the place, which spin-off firms could occupy in the structure of national innovation system, it would be reasonable to ask, whether, and in what way, their establishment should be stimulated. Striving for objectivity, one should bear in mind the limited financial possibilities of organisations in the unstable transitive economy, and estimate rationally the genuine opportunities to contribute to spin-offs development.

Anyway, what LPRIs can really do is providing the start conditions for innovators' work, the legal framework for their activity, and possible assistance with manufacture areas renting and equipment leasing.

As concerns the equipment, necessary for spin-off firms' specialization, additional problems arise. The installations employed are usually the developments of researchers (founders of spin-offs) created during their work at the academic research institutes; they are often very complex and expensive. Their value has been thus created by combination of innovative ideas of scientists and financial contribution of research institute. Being now in state' ownership, the installations are used by innovators in their activity at private-owned firms.

To keep this equipment at the research institutes and not to make use of it in the economic activity would be the an unpardonable mistake for the innovation policy, targeted at the sustainable development of the whole system, and a typical example of missed opportunities costs for the transformation economy. Nowadays many installations, which are unique not only in the country, but also on the world level, are in the non-active or inapplicable state. Passing them from LPRIs to spin-offs on advantageous terms (for the innovators have usually no funds sufficient to buy them on their whole price, and without these installations they cannot conduct the innovation activity in a normal way), would be the best measure for strategic, rational country' resource allocation.

The most common problem the innovators face is that customer enterprises are usually insolvent. That is the reason why the innovators do not wish to take any credit for conducting strategic research – neither in bank, nor in innovation foundation, nor elsewhere: the threat that they will not be able to sell the innovations, and give the credit back is great.

To provide the researchers with the start capital and economic advantages would certainly be of use, but the initial conditions for successful innovation process would be elimination of the red tape, and raising of the responsibility of state bodies at collaboration with small innovative firms.

### **Integration into society**

Apart from factors of financial and institutional nature, the social factor has a huge impact on the sustainability of the national innovation system, which is being built nowadays.

No qualified experts in the sphere of innovative projects in general, and scientific projects in particular, are trained in Belarus. Rare are the experts who would be able both to understand the technological process, and to support and give economic estimation to innovative projects and scientific technical programmes. Researchers, who have established the small innovative firms, are initiative, full of enthusiasm and able to cope with the problems inherent to transitive economy. But, researchers and scientists are not the best businessmen. Their new status requires as well the skills of managing the research group, and

marketing activity on study of enterprises' needs in technologies and products to be developed. However, they rarely possess all the necessary business skills, and often need the external support in order to improve their financial and marketing skills.

### **Conclusions**

Vitality and effectiveness of innovation systems have always depended on **how efficient the flow of information** between its participants is. **Access to relevant information** is thus one of the critical conditions of successful operation of an innovation system, either on local, national, or European level.

An additional barrier for increase of innovativeness is weak knowledge of economic actors of the legislative decisions regulating the research and innovation activity; especially in the case of small private-owned companies there is a problem of taking account of all the legal changes and calculating their influence on economic activities. The lack of required information results in imbalance of supply and demand concerning scientific production, and in the majority of cases in general makes the probability of innovation activity equal to zero.

One of the most effective tools of supporting and encouraging the innovations is therefore an **information** campaign addressed to businessmen, though its conducting is often kept for a trivial waste of tax bearers' funds. The campaign should be however thoroughly thought over, and the force of the information and in negative sense should be taken into account. If the information is not authentic, contradictory or even overabundant, it may cause the *disorganisation* of activity.

The accessibility of information becomes useful only where and when the **ability to absorb and integrate the knowledge diffused** to the production process exists. This proves once again, that in innovation system, the roles and responsibilities as for knowledge diffusion should be coherently and consistently distributed between the decision-makers – universities, research institutes, enterprises, and all the intermediate links, as spin-off firms and innovation infrastructure institutions.

Ignoring these features of an innovation process, we risk achieving the innovatively cut-off country, being not able to deal with advanced environmentally friendly and socially compatible technologies, neither having an idea of how to improve the situation.

It is therefore of utmost importance to realize, that innovation system needs somewhat different from just promoting of innovations' introducing in industry and development of science-intensive technologies – the background of its success is rather the innovativeness of mind of the society, involvement of the society into innovation process, society's openness to innovations.

**The report is based on empirical investigation of small innovative enterprises of Belarus, carried out during the interviewed study by INTAS (project 99-00943 Innovation, SME's and economic development in Ukraine and Belarus"). I would like to express my sincere gratitude to Dr. Anton Slonimski, for his patience, support, and scientific supervision during the investigation.**

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