

INDICATORS FOR EVALUATION OF RESEARCH RESULTS APPLIED IN PRACTICE

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Abstract:

There exist still different views between communities of research and management in Vietnam toward the evaluation of a research task which is considered as having been applied in life and production practice. On basis of surveys made among leads of national level research tasks, this paper aims at introducing indicators used for evaluation of the actual status of application of R&D research works in life and production practice.

Keywords: Research results; Application of research results; R&D.

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1. Introduction

The Resolution of the Party Second Conference (Session VIII) on strategic directions of science and technology (S&T) development decided the creation of a S&T market as one of the main solutions for S&T development of the country. The 10th National Party Congress states “*development of S&T market on basis of renovation of mechanisms and policies to turn majority of products of scientific research into commercial goods*”. The 11th National Party Congress again confirms “*strong development of S&T market to be linked to protection of Intellectual Property (IP) rights*” which would give contributions for improvement of the socialist oriented market economy institutions in our country. The Resolution of the Sixth Conference of the Party Central Committee (Session XI) on S&T development once again confirms the development of S&T market as one of the main tasks and solutions for S&T development of the country. Furthermore, the 12th National Party Congress defines “*strong push-up of S&T research and application and innovations*” as one of the central directions and tasks for socio-economic development of the country for the 2016-2020 period.

The Party and the State focusing attentions for these orientations secure the allocation of 2% of the annual State budget, as the minimal rate, for S&T

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sector (*Ministry of Science and Technology, 2017 - MOST*). However, there exist many different points of views among communities of scientists, managers, enterprises and large population on the actual status of application and transfer of R&D research results in life and production practice. Many views from enterprises and large population still consider that there is a very low rate of State budgeted research projects, after having passed successfully the acceptance procedures, which get applied and transferred in life and production practice. At the 12th June 2015, in the meeting of the National Congress, the question on “drawer-closed research projects” (a term used largely in Vietnam to say about the useless research works) had been addressed to MOST.

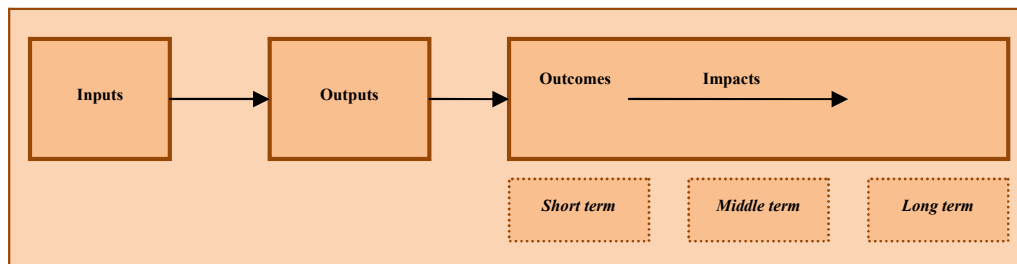
In certain circumstances, the points of views as well as assessment by part of social communities in evaluation of results of research tasks are not found suitable yet. Then, the answer to the question “What is a research task which is evaluated as having been applied in life and practical practice?” needs to be clarified. Apparently, the answer seems to be simple but, in practice, there exist many differences of views among communities of scientists, managers and enterprises. This paper will propose some indicators for evaluation of the actual status of application of R&D results in life and production practice.

2. Scientific background for definition of indicators for evaluation

For definition of indicators for evaluation of the actual status of application of R&D results in life and production practice, first of all, we should consider the model of evaluation of R&D activities applied by the EU and many other countries which includes the sequence of the factors input - output - outcome - impact (Figure 1). Here, the *Inputs* include financial and human resources for R&D works; the *Outputs* include tangible or non-tangible products made from R&D activities such as technologies and publication works; the *Outcomes* include results or consequences of R&D activities such as the number of citations made by other research works and incomes generated from commercialization of outcomes of R&D works; the *Impacts* include outcomes in middle and long term visions such as influences of R&D activities to productivity rate of enterprises or improvement rate of eco environments. For evaluation of efficiency rate of R&D activities, many countries and international organizations build up various sets of indicators for evaluations as indicated in Figure 1.

It is necessary to note there is no direct causal relation between groups of indicators. In practice, it is not necessary to have all the R&D activities to create innovations and, inversely, there exist innovations which are not based on R&D activities. More than that, the inputs in this system of

indicators do not need compulsorily to create outputs, outcomes or impacts during the years they are conducted. Input materials and outcome products may be impacted by external environment factors which decision makers even are unable to control. For example, when quantifying effectiveness of a development project, the impacts of external economic factors (such as financial crisis leading to higher prices for outputs of the project), in fact, are really difficult to be controlled.



Source: DASTI (2014)

Figure 1. Model of evaluation of the actual status of application of R&D activities

The indicators for evaluation of the actual status of application of R&D results in life and production practice are a group of indicators in a system of indicators for evaluation of R&D activities on basis of the model of the “input - output -outcome - impact” sequence. One of the key words of this research is “*application of research results* (in life and production practice)” which means that the R&D tasks had created certain products and the focus of evaluation works is to set up a set of indicators for evaluation of application of R&D tasks in S&T fields. For example, a research task had produced an active composition named as A and this active composition is applied to produce a drug named as B then the drug being commercialized in market give contributions to treat the disease C and etc. which illustrate well the sequence.

For consolidating the argument for definition of indicators for evaluation of the actual status of application of scientific research results in life and production practice this research further clarifies the meaning of “application of research results in life and production practice”. *Nguyen Quang Tuan (2016)* said that the application of research results can be divided into three different categories, namely: (i) Research results which are used for another R&D research task (the latter may be deeper or larger in terms of scientific contents or higher applicability); (ii) Research results which are used to serve certain public interests or non-money-measured purposes; and (iii) Research results which are commercialized.

The view that the application of R&D results in life and production practice can be conducted in various rates gets the consensus of many researchers in the world. For example, *Tijssen (2009)* indicated that many research activities bring high values for users but do not get the adequate recognition among academic communities as it should be in normal ways. Also, from the view by the author of this research, a research work may cause impacts to many targets including scientific communities, economic systems and the whole society. These impacts may be exhibited in direct and/or indirect ways, in immediate vision and/or extended vision. Some direct and immediate impacts of a research work can be quantified by certain indicators such as indicators for evaluation of research results or economic indicators of a new technology or improved technical method. However, there are many impacts, even being classified as direct, needs a longer time to be recognized as effective and efficient. In this optics, indirect and/or extended vision impacts should be more difficult to get classified as proven.

In Vietnam's society, the application of research results in life and production practice is a topic which gets high attentions from individual researchers, organizations and mass media. A part of our society may identify two different notions: (i) Application of research results in life and production practice; and (ii) Commercialization of research results. Also the applications which are classified as indirect and difficultly noticed do not get adequate interests from the society. Some research results which do not get applied directly or immediately in life and production practice may have high values because they enrich the knowledge and skill base of the nation and the world. This knowledge, enriched and accumulated, can become direct producing forces in a later time.

The notion discussed above shows well that the first notion - the application of research results in life and production practice - is a very large notion which includes numerous and different aspects and forms of application. The application of research results may be conducted through many different ways such as publications for propaganda works, education works for higher social awareness; teaching materials for education and training works; cooperation for research works, contracts of research works, technological consulting services; technological licensing; establishment of S&T enterprises and joint ventures (*Cripps et al., 1999*) or use for another R&D works of a deeper level of research and many other forms as discussed above (See Table 1). For the second notion - the commercialization of research results - the development policies of many countries are focusing on promotion of this direction. However, the exaggerated attentions which reserve efforts for direct applications and which could leave the indirect forms of application aside could be a serious

mistake in terms of policies. *DASTI (2014)* noted that the commercialization of R&D results is only a minor segment in use of research results in life and production practice.

Table 1. Forms of application of research results

Application for R&D projects	Application for public and non-money-measured interests	Commercialization
References for citation by other research works	Post-graduate training materials	Technology licensing
Inputs for other research projects	Set-up of training courses/ programs from research results	Creation of S&T enterprises
Suggestion of ideas for other research projects	Propaganda programs/plans for higher social awareness	Turn-key purchase of research results
Research cooperation	Impacts to actions of decision makers	Conclusion of contracts of consulting and designing services from research results
	Improvement of development policies	Conclusion of agreements for Joint Ventures from research results
		Gaining financial supports for other research projects from research results

Source: Summary from Cripps et al. (1999) Ruegg, 2000; FLC, 2009; Huges et al., 2011

Holi et al. (2008) proposed a model of knowledge transfer from research sector to other economic sectors and explained that the activities of knowledge transfer do not directly create economic impacts but help other actors in the innovation system to create economic impacts. Therefore, it would be a one-sided approach if the assessment is based only on economic or commercialization indicators to make forecast for impacts in future or for impacts from policies. The outputs of a research work include knowledge newly created in form of publications, new procedures, new technologies or technical know-hows and added values of knowledge the researchers may produce in their research activities. While building up the set of indicators for evaluation, *Holi et al. (2008)* used the approach with involvement of the groups of concerned actors including representatives of knowledge transferring sides (directors and senior managers of universities), research funding sides (research sponsors) and knowledge receiving sides (communities of enterprises). The consensus of these three sides on the notion, approaching ways and matrixes of indicators for

evaluation would be considered as the most typical success in the process to build up and to apply the set of indicators for evaluation of research results by universities in the UK, the US and Canada.

Table 2: Some indicators for evaluation of application of research results as contribution for the related sectors and commercialization services

Indicators of trained human resources	Cooperation between R&D organizations	Commercialization of research results
Number of graduates working in industrial sectors	Number of R&D contracts signed with enterprises	Number of granted patents
Number of doctors working in industrial sectors	Benefits and incomes from contracts of consulting services	Number of granted licenses
	Number of established spin-offs	Number of established spin-offs
	Number of works with co-authors from industrial sectors	

Source: Finne et al., 2011

Finne et al. (2011) used the model proposed by Holi et al. to build up the set of indicators for evaluation of knowledge transfer works. However, the application was made only for three mechanisms of knowledge transfer, namely: (i) Transfers made through researchers; (ii) Transfers made through joint research projects; and (iii) Transfers made through activities of commercialization of research results (see Table 2). This group of researchers proposes a set of indicators for evaluation which integrate single indicators where the evaluation of advantages and disadvantages of every indicator, the availability rate of data and the challenge from data sources are provided. This set of indicators for evaluation passed the test for data samples from universities and a mechanism to maintain monitoring activities was proposed for management units of these universities. In a global view, the indicators target the beneficiaries (communities of enterprises) of all the three mechanisms of knowledge transfer.

On basis of the model “input - output - outcome - impact”, Tijssen (2009) proposed another set of indicators of evaluations of R&D activities of Australia which include: (1) Turnovers generated from research activities; (2) Working human staffs; (3) Number of staffs which generate turnovers; (4) Number of staffs which produce publication works; (5) Number of staffs which are qualified to supervise thesis and research works of doctor grade students; (6) Number of staffs which are qualified to supervise thesis and research works of post-graduate students; (7) Number of research fields which have strong positions; (8) Number of graduate student and doctor

grade students in research fields which have strong positions; (9) Commercialization activities in the university; and (10) Number of patents granted to the university. Obviously, these indicators give hints for Vietnam to build up its set of indicators for evaluation of application of R&D research results.

3. Process of definition of indicators for evaluation of the actual status of application of research results

The indicators for evaluation of effectiveness of an activity in general and scientific research activities in particular are basic units to identify the effectiveness rate. According to *Tijssen (2009)*, the procedure to build up the set of indicators for evaluation needs to follow the SMART principles (S - specific, M - measurable, A - attainable, R - realistic/relevant, and T - timely/time). The other indicators which have to be achieved should include: objective data and information, clear methodology, possibility to compare (comparability of indicators), feasibility of solutions and effective costs for implementing staffs and users (accessibility to data, capacities to cover large areas, possibility to supply assured values and possibility of verification).

On basis of the above presented scientific background and principles to build up the indicators for evaluation, this research proposes an initial set of indicators for evaluation of the actual status of application of R&D results in life and production practice in Vietnam, namely:

(1) *Indicator of cited references*: This indicator can be used for all the scientific research sectors and types of research works (fundamental research, applied research and experimental development). This is the indicator for evaluation largely used by S&T organizations in the world. This indicator would certify that a research works is classified as to have applications if it is cited as reference at least by one other research work. The more the research work gathers citations the higher it has the value of application.

(2) *Indicator of heritage of research results*: The number of cited references, as indicator for evaluation, provides a global evaluation of related research works in realization of R&D tasks which reflects the heritage of previously made research results. The author and the research team added this indicator for evaluation because the practice shows many cases where research results are transferred to another research work which has deeper research contents or higher applicability. For example, a research task in agricultural sector has created some good species from which other experts using some other methods (e.g. radioactive treatment) produce some other varieties for application in life and production practice. In this case, the research work, if

having at least one other research work which gets partial or full heritages from its research results, is classified as to have application in life and production practice. As it is for the first case, the more the research work produces heritages the higher it has the value of application.

(3) *Indicator of contribution to post-graduate education*: This indicator for evaluation is related to development of human resources which is used largely by many countries and international organizations for evaluation of programs of post-graduate formation. The more the research results are introduced into training programs of post-graduation formation the higher it has the value of application. In some cases, it is necessary to introduce a rating system (maybe scores) for post-graduate formation programs of different training organizations.

(4) *Indicator of social interpretation and enhancement of social awareness*: This indicator of evaluation can be applied for all the scientific sectors. For example, the social interpretation work is an important function of social sciences and humanities. They help change the behaviour of part of the social communities in a more positive and healthy way of social conducts. The fundamental sciences and the technical-technological sciences are also useful in social interpretation works. For example, when a mass media gives sensible and hazardous news that “litchi may cause *Japanese encephalitis*”, researchers in sectors of natural sciences and technical-technological sciences can give interpretations from their research results to show that the news simply gives wrong information. It is clear that this social interpretation has a huge value of application in life and production practice because it can save numerous households from economic damages in litchi cultivating areas in Luc Ngan and Thanh Ha Districts in North Vietnam. The indication of this indicator is the number of references to this interpretation by communication media, mass information organizations and individuals in their programs.

(5) *Indicator of direct application in life and production practice*: It is one of the indicators for evaluation largely used in practice. For example, the provided solutions are used to settle some problems arising from social life and practice such as medical treatment procedures applied by hospitals for patients, improvement of technological and production procedures applied by enterprises to achieve a higher productivity rate and better quality of products/services.

(6) *Indicator of improvement of policies*: The research works are classified as to have application in life and production practice if their research results are used in a concrete text of documents and regulations issued by the Party and the State. However, in many cases, research results are not applied

directly in life and production practice. In fact, they may, through certain cycles of activities, cause effects to policies and to social communities. For example, some research results are forwarded to the National Congress members and make certain of them turn their views to the directions suggested by the research results. Then the research works are classified as to have application if their research results are used by policy makers for their decisions.

(7) Indicator of consulting service: Organizations and individual experts, on basis of their research results, may conclude a contract of consulting service or financial supports for a new scientific task. This would be an indication for this indicator. This indicator for evaluation can be used for all the sectors of science including social sciences and humanities, fundamental sciences and technical-technological sciences. The case of successful conclusion of “consulting contracts” is popularly as indicator in other countries and in Vietnam. For example, from the results of a national level research task in sector of manufacturing, the reputation and the skills of the project hosting organization would get higher which help it to win another business contract valued many time higher than the costs the State paid to complete the assigned research task.

(8) Indicator of lump-sum transaction: This indicator is also among the ones largely applied in transfer and commercialization of research results. In this case, the buyers have full rights to exploitation and commercialization of transferred research results from research hosting organizations and individual experts. Actually in Vietnam, the direct purchase of research results is difficult to have place since the ownership of results developed from State budgeted research tasks as well since the rights to own and to use them are assigned to the State representatives which are Ministers or Chairmen of Provincial People’s Committees.

(9) Indicator of transfer of rights to ownership and use (licensing): This case of contracts of licensing is a form of “commercialization” largely popular in the world. As the case presented above, this case is difficult to have place in Vietnam in the actual stage due to the existing regulations toward the ownership rules of State budgeted research tasks.

(10) Indicator of creation of S&T enterprises on basis of research results: The creation of S&T enterprises (mainly related to establishment of spin-offs) is a form of “commercialization” of research results largely applied in the world.

These 10 indicators for evaluation of the actual status of application of research results in life and production practice as presented above were in focus of multiple discussions by the author of this paper together with a

research team of National Institute for Science and Technology Policies and Strategic Studies. The set of indicators for evaluation was sent to some S&T organizations for further assessment. A rating system (scores) for assessment of replies was prepared, namely: 5 for high level of agreement for indicators, 4 for rather high level of agreement, 3 for middle level of agreement, 2 for low level of agreement and 1 for disagreement. The replies with attached comments and contributions were received from 8 S&T organizations for the draft of this set of indicators for evaluation. The summary of these replies is presented in Table 3.

Table 3. Views and remarks by S&T organizations on the indicators for evaluation

No.	Indicators	Average scores (1-5 score scale)
1	Number of citations	4.25
2	Heritage of research results	3.63
3	Contribution for post-graduate formation	4.00
4	Social interpretation and enhancement of social awareness	3.75
5	Improvement of policies	4.00
6	Direct application in life and production practice	4.00
7	Consulting contracts	3.75
8	Lump-sum transaction	3.73
9	Licensing contracts	3.50
10	Creation of S&T organizations from research results	3.50

Source: Survey data by the author and research team

Basically, all the 10 indicators for evaluation get comments and remarks from the surveyed S&T organizations with certain consensus level of views. The lowest score (3.5) was even higher than the score of the middle level of agreement and the overall average score (4.25) is higher than the score of the rather high level of agreement. The indicator for the number of citations gets the highest average score. However, some comments say that this indicator is difficult to be applied in Vietnam. Meanwhile, the author and some experts evaluated that it is necessary to introduce this indicator into the set of indicators for evaluation where it would give contributions to push up the creation of norms for citation of research works and use of references with a perspective of transparency and openness of research results.

The surveyed S&T organizations provided certain comments and remarks for some indicators. Namely, the indicator of “heritage of research results”

which should be addressed carefully to avoid copying practice. The indicator of “contribution for post-graduate formation” should be rated as basic indicator for evaluation of applicability of a research work in sector of social sciences and humanities. Some comments also state that the indicator for “social interpretation and enhancement of social awareness”, by its nature, includes “the applicability” in sector of social sciences and humanities.

However, the indicator of “licensing contracts” and the indicator of “creation of S&T enterprises from research results” do not get high comments and remarks despite a very large application of these indicators in developed countries. One of the reasons may come from existing regulations which assign the rights to ownership and use of research results to Ministers and Chairmen of Provincial People’s Committees.

Applying this set of indicators for evaluation, the author and the research team of National Institute for S&T Policies and Strategic Studies develop a set of detail questions on the actual status of application and transfer of R&D results in life and production practice. The questionnaires were sent to the leads of national level scientific research tasks which passed the acceptance formality during the 2006-2015 period. We had identified that, during this period, 407 scientific research tasks in total were filed in the National Center of S&T Information, MOST. Then the author and the research team sent the questionnaires to the leads of scientific research tasks and received 163 replies from them. Among them, 41 tasks were completed in sector of social sciences and humanities, 36 tasks were made in sector of natural sciences and 86 tasks were made in sector of technical-technological sciences (see Table 4).

On basis of the collected data the author and the research team defined that there was no contract officially signed between S&T organizations and enterprises according to the above defined indicator of “direct application in life and production practice” and the one of “consulting contract”. There were only non-official contracts between the leads of research tasks and users and the products produced and transferred were not also the whole set of research results of the research tasks. The agreement concluded between the leads of the tasks and users are only part of research results or part of research results plus the knowledge accumulated previously by the leads of the tasks. Therefore, the indicator of “direct application in life and production practice” and the one of “consulting contract” should be combined in one which should stipulated as “non-official application” in life and production practice (see Table 4).

Table 4. The actual status of application of national level scientific research tasks in life and production practice which had passed the acceptance formality during the 2006-2015 period.

Indicators for application	Sector of science		
	Social sciences and humanities	Natural sciences	Technical-Technological sciences
Citation by other research works	18 (43.9%)	11 (30.5%)	23 (26.7%)
Heritages by other research works	39 (95.1%)	28 (77.7%)	65 (75.5%)
Contribution for post-graduate formation	25 (60.9%)	21 (58.3%)	34 (39.5%)
Social interpretation and enhancement of social awareness	10 (24.4%)	7 (19.1%)	31 (36.0%)
Improvement of policies	37 (90.2%)	0	0
Non-official application if life and production practice	1 (2.4%)	11 (30.5%)	24 (27.9%)
Lump-sum transaction	0	0	5 (5.8%)
Licensing contracts	0	3 (8.3%)	2 (2.3%)
Creation of S&T enterprises	0	1 (2.7%)	3 (3.4%)
Research results with potentials of applicability	4 (9.7%)	13 (36.1%)	42 (48.8%)
Total (N):	41	36	86

Source: Survey by the author and research team

Table 4 shows that 100% of research results in the sectors of science are used by other research works under forms of citation or direct heritage of previous research results.

According to the group of indicators of creation of products/services for public interests of the society show that 100% of research results give contributions to creation of public products or services or other non-money-measured interests. For example, for research tasks in sector of social sciences and humanities, according to the indicators, 60% of the leads of scientific research tasks state that their research works produce contributions to post-graduate formation; 24% of the scientific research tasks give contributions to social interpretation and enhancement of social awareness and 90% of the scientific research tasks provide contributions to improvement of policies. In regards to the group of commercialization of scientific research in sector of natural sciences, 30% of the scientific research tasks get commercialized non-officially and the ones of official commercialization make only 11%. In sector of social sciences and humanities, the corresponding figures are respectively 28% and 20%. Therefore, it is possible to define the rate of commercialization (official) of

S&T tasks at national level which passed the acceptance formality during the 2006-2015 period is about 11-12% of the total number of tasks.

For the group of “research results with potentials of applicability” there is a relatively big number of about 36.2% (59/63) of scientific research tasks which provide certain extents of application in life and production practice according to these indicators. Here, “potential of applicability” includes the following cases: (i) research results completed in laboratory scale but having no conditions for final completions; (ii) research results ready for application but having no identified partners for transfer or application; (iii) research results ready for application but being incapable of being implemented due to troubles in standards, technical norms, prices or fluctuation of markets. The rates of “research results with potentials of applicability” are very different between sectors of sciences. For example, the rate is not big for social sciences and humanities (9.7%) but it is considerably big (36.1%) for sector of natural sciences and technical-technological sciences (48.8%). The rate of “research results with high potentials of applicability” put new problems for policies to enhance effectiveness of R&D activities.

4. Conclusions and recommendations

The brief summary of the above analysis show that the indicators for evaluation of the actual status of application of R&D scientific research in life and production practice are a set of indicators in the system of indicators for evaluations of R&D activities at the national level. After a deep assessment of this research the author and the research team proposed a set of indicators for evaluation of the actual status of application of R&D scientific research for use in Vietnam which includes: (1) Indicator of citations; (2) Indicator of heritages; (3) Indicator of contribution for post-graduate formation; (4) Indicators of social interpretation and enhancement of social awareness; (5) Indicator of improvement of policies; (6) Indicator of non-official application in life and production practice; (7) Indicator of lump-sum transactions; (8) Indicator of licensing contracts; and (9) Indicator of creation of new S&T enterprises. Here, the indicators for evaluation from 6 to 9 are used as the indicators for commercialization of R&D research results. The indicators used for evaluation of research tasks in sectors of social sciences and humanities are the ones from 1 to 5. The sector of natural sciences uses indicators (1), (2), (3), (4), (6), (8) and (9). The sector of technical-technological sciences uses indicators (1), (2), (3), (4), (6), (7), (8) and (9).

It is necessary to note that every sector of science has always three typical fields of research, namely: fundamental research, applied research and

experimental development². We need to introduce a system of weight factors for specific fields of every sector. For example, for the sector of fundamental research, *OECD (2015)* specified that the essential feature of fundamental research is that it has no concrete objectives for application. As always, the research results of fundamental science research works are published in scientific magazines and/or used as teaching materials in universities. Then the application of high weight factor for the indicator of commercialization for fundamental research tasks is found unsuitable.

The set of indicators for evaluation is proposed for temporary use and it can be applied for evaluation of the actual status of application of results of State budgeted research tasks in life and production practice. This research recommends competent organizations to make a test use of the set within certain period. A deep and exhaustive assessment of tests conducted by S&T organizations is highly required before the set of indicators for evaluation will be issued for official use.

This research, on basis of the above analysis, proposes the following recommendations: (i) The competent organizations in particular and the whole society in general should have a larger open vision toward the application of State budgeted R&D research results in life and production practice where the commercialization of research results is only a minor segment in the actual status of this application process; (ii) The State and research tasks hosting S&T organizations should have suitable policies to encourage scientists to turn proactively non-official applications to commercialized products on basis of officially issued regulations; and (iii) The State should revise and amend finance-investment policies and management mechanisms for S&T tasks. These measures would offer favourable conditions to get a lower rate of research results classified as “having potential applicability” and give contributions to lead the research results to the final destination of use./.

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