Designing and implementing future scenarios: Foresight methodology, economics, technologies, society,and ecology

Shevchenko, Yelena and Pomogaev, Vitaly and Stukach, Victor and Nikulin, Danil

Omsk State Agriculture University, Omsk, Russia, Department of Center for Technology and Innovation Development, National Agency for Innovation Development "QazInnovations", Nur-Sultan, Republic of Kazakhstan, Bauman Moscow Sate Technical University, Moscow, Russia.

September 2017

Designing and implementing future scenarios: Foresight methodology, economics, technologies, society, and ecology.

Yelena V. Shevchenko[1], Vitaly M. Pomogaev[2], Victor F. Stukach[3*] and Danil S. Nikulin[4]

[1]Department of Center for Technology and Innovation Development, National Agency for Innovation Development "QazInnovations", Nur-Sultan, Republic of Kazakhstan.
[2]Omsk State Agriculture University, Omsk, Russia.
[3]Department of Management and Marketing of the State Educational Establishment, Omsk State Agriculture University, Honored Worker of the Higher School of the Russian Federation, Omsk, Russia.
[4]Bauman Moscow Sate Technical University, Moscow, Russia.
*Corresponding author: E-mail: vic.econ@mail.ru;

Abstract

The article discusses several aspects of incorporating foresight into the science, technology, and innovation (STI) policy planning process, as well as a set of recommendations for managing uncertainties and ensuring policy alignment with society's future needs. The goal of this study is to investigate the role of technology foresight in decision-making and to develop recommendations on how to effectively integrate national foresight into the process of STI policy planning. Innovation has emerged as a key driver of global economic development, and it continues to be at the forefront of technological breakthroughs. Developed countries are increasingly focusing their efforts on research and development (R&D) in areas that will determine megatrends of technological and social progress in the coming decades. To identify key priority areas foresight brings together key agents of change and various sources of knowledge. Foresight is not aimed at providing an accurate prediction of the future, but allowing to design alternative scenarios of possible futures and to elaborate policies and strategies to achieve "the desired scenario".

The paper states that foresight provides a basis for STI policy planning by identification of key areas for long-term investments and assessing long-term perspectives of science, technology, economy and society development.

Keywords: Designing future scenarios, Foresight methodology, staging the future in the economy and social sphere, the scenario of the future in ecology.

1. Introduction

Issues concerning the integration of technology foresight into the policy planning process have received little attention in academic papers, despite the fact that they are critical for decision-makers. The purpose of this paper is to discuss various aspects of incorporating foresight outputs into decision-making processes and to deliberate recommendations for improving the efficiency of strategic policy planning based on foresight.

Foresight is a systematic, participatory, future-intelligence-gathering and medium to long-term vision building process aimed at present-day decisions and mobilization of joint actions. Foresight brings together key agents of change and various sources of knowledge in order to develop strategic visions and anticipatory intelligence. Foresight has gained much attention as a tool for developing and informing science, technology and innovation policy and company strategies. It is frequently used for detecting not only potential development paths of technologies but also possible economic and societal changes; and for identifying challenges that nations, societies and companies might face in the future [1-3].

A prerequisite for a successful foresight is an existence of developed civil society. Foresight requires active participation of all stakeholders based on the exchange of views among different actors aimed to reach consensus on the topic under investigation.

At the same time, foresight is not aimed at providing an accurate prediction of the future but allowing to design alternative scenarios of possible futures and to elaborate policies and strategies to achieve "the desired scenario". Implementation of "the desired scenario" depends on the decisions taken at the present because choices that made today will affect the level of development in the future. In this regard, foresight serves as a tool for mobilization of all actors of the national innovation system in the process of long-term vision-building with the purpose of translation of desirable directions into action. However, practically the importance of linking foresight to the policy planning is still underestimated and there is a need to design methodologies for integration of the foresight into the policy planning. The incorporation of foresight methodologies into the planning process will ensure greater level of decision-making flexibility and commitment to proposed plan of actions.

Policy-makers face a challenge of development policies and strategies which allow better allocation of limited resources to support promising research areas and emerging technologies that will boost social and economic growth [4]. To design future-oriented policies technology foresight (TF) was proposed as an appropriate method to manage STI development on the country level.

Foresight is used in different contexts (national, regional, organizational) to anticipate changes and create a basis for elaboration responses to them [5]. TF on the national level helps to identify key scientific and technological areas that ensure sustainable development in the future. Thus, TF can be viewed as a systematic attempt to observe the long-term future of STI and identify emerging technologies that will probably provide the greatest economic and social benefits.

In terms of STI development, “technology foresight can be regarded as the most upstream element of the technology innovation process. It provides inputs for the formulation of technology policies and strategies that guide development of the technological infrastructure. In addition technology foresight provides support to innovation, and incentives and assistance to enterprises in the domain of technology management and technology transfer, leading to enhanced competitiveness and growth” [6].

The results of foresight activities provide evidence-based recommendations for decision-making process. Challenge of the implementation of foresight outputs relates to the translation of its results into concrete decisions for policy-making, because policy-makers usually focused on short- and medium-term urgencies and foresight has a long-term focus. Based on the analysis of foresighting activities conducted in Chine Li N. claims that technology foresight provides a comprehensive platform to collect ideas and suggestions for development policies and strategies, but technology foresight and S&T planning methodologies still have vast room for improvement [7].

Foresight can help to reach consensus among stakeholders about priorities for investment pathways. As pointed by Kirk Weigand, Thomas Flanagan, Kevin Dye and Peter Jones [8] strategic investments pathways might be identified from the foresight based on the mapping of cross-impact analysis (leverage among solutions to challenges) and reachability analysis (leverage of solutions to influence the network).

Sutherland and Woodroof [9] described that horizon scanning should be incorporated into research, policy and practice. They also pointed that decision-makers have appropriate tools for identifying forthcoming problems and opportunities they will be able to make timely actions to minimize damage and maximize benefits.

Incorporation of TF results into industrial strategy aimed to shape technological change and economic growth. In this regard technology foresight and industrial development strategy should be coherently designed and implemented.

Foresight is aimed to help policy-makers understand environmental uncertainties, identify major drivers of change and prepare plan to reach desired future. TF outputs such as scenarios, technology roadmaps, lists of critical technologies are used in elaboration of action plans that support an implementation of policies and strategies. Roadmaps consist of representations of interconnected nodes of major changes and events in selected fields, i.e. science, technologies, markets and products [10]. Roadmaps are a powerful tool of policy planning that help to optimize the final planning based on the assessment of many parameters such as financial resources available, scientific, technical and social needs.

Based on technology prioritization methodologies technology roadmaps provide policy-makers with logical and quantitative instruments to verify choices of prioritization and assist them in prioritization of investment in advanced technologies. Roadmaps used to support the development of future oriented analysis by linking technology, policy, business and social drivers and enabling better understanding of uncertainty and elaborating more effective policy responses [11]. At the same time technology roadmaps are closely linked to scenarios that help to explore uncertainties and to consider how current trends and drivers might shape the future [12].

2. Experience of Singapore and south Korea in implementation of foresight results

2.1 Foresight for STI Policy Planning – Case of Singapore

Foresight seeks to foster economic impact by enhancing the network between industry, academia, government and the society. The results of such networking activities under the umbrella of foresight should be considered at the stage of strategic policy elaboration.

Among the emerging economies Singapore and South Korea represent good examples of integration of the national foresight results into strategic planning process that caused rapid technological development.

Integration of foresight results into STI policy is still a challengeable issue for many countries. The ability to effectively exploit results of foresight is hampered by the limitations of governance systems to take into account the complexity in the definition of public policies. In such a context, foresight needs to be more thoroughly integrated into the policy making process to be effective.

In Singapore in 2005 year was initiated Program of risks assessment and horizontal scanning. This Program implemented under the principle of cooperation and collaboration between all government institutions that were obliged to conduct risk assessment and horizontal scanning in a strong collaboration [13]. The Risk Assessment and Horizon Scanning system was designed to network multiple agencies together and provide advanced data analytics [14]. Foresight exercises in Singapore provide a basis that helps the Singapore government to navigate emerging strategic challenges and harness potential opportunities. Foresight and future analysis are widely used in Singapore. To conduct the foresight and implement the results in the strategic planning process, special centers under the government institutions were set up. The Risk Assessment and Horizon Scanning Programme (RAHS) set up in 2004 to complement scenario planning. RAHS scans the horizon for weak signals of potential future shocks, and detects emergent threats and opportunities through a suite of technology-based methods and software[1]. In 2010 year, the Center of Strategic Analysis of the Future was established with a mandate to coordinate national foresight activities, elaborate, implement national policies and strategies and develop foresight capacities in the country.

In Singapore national foresight is conducted periodically through scenario planning, as well as continuously through environmental scanning or horizon scanning. Scenarios explore key areas of uncertainty and include an action-plan in relation to the scenario “signposts”. Using scenarios in national foresight exercises integrates anticipation of changes, visualization of different pathways and planning for the desired future. Scenarios as an output of national foresight exercises became an

essential part of the national STI policy planning. On the other side, the RAHS Programme helps to improve knowledge and information sharing process and together with foresight exercise became an essential part of strategic planning process on the country level [15].

2.2 Foresight in STI Policy Planning – Case of the South Korea

Integration of S&T foresight in the national policy planning process promoted fast STI development in South Korea. Foresight activities conducted in South Korea are qualitatively different from the linear forecasting models that were broadly used by government of many countries in 1950-1960 years. In contrast to previously used forecasting methods aimed at identifying the unique direction for the future development, foresight in Korea was used for elaboration of alternative scenarios of possible futures. Scenario building process was based on analysis of trends and different factors that can influence the path of the future, investigation of treats, opportunities, needs, challenges and risks the society may face in the long-term and followed by designing of recommendations to address future challenges. Foresight in South Korea focused on matching future needs of the society with appropriate technological developments.

Foresight in Korea is not based on extrapolation of the existing model of development. It is based on the recognition of high uncertainty of the future and identifying possible directions for the future development as well as designing specific policies and strategies to achieve the desired vision of the future. In South Korea foresight has a central role in formulation of S&T policies and strategies.

The experience of South Korea provides an example of effective implementation of national foresight results. The initiator of the national foresight is Korean government. Foresight exercises are carried out with an active participation of public, private sector and representatives of the society.

There are two government agencies responsible for implementation of foresight exercises in the country. Korea Institute of Science and Technology Evaluation and Planning (KISTEP) manages National S&T foresights in Korea and links the results of the national foresight to STI policy of the country. KISTEP in foresight focuses on long-run S&T priorities setting. The same time Korea Institute for Advancement of Technology focuses on foresight for elaboration of technology development roadmaps in short and medium run [16]. In this way, outputs of national S&T foresight in Korea had been incorporated into strategic policy planning process on the country level.

Among the most successful national foresights in South Korea should be noted foresight activities conducted before the implementation of Highly Advanced National Project (HAN Project) in 1992 year. The HAN Project was aimed at lifting Korea's technological capability to the level of G-7 countries by 2020 year. It was a large-scale and long-term R&D project, designed as an inter-ministerial program under the National R&D program framework. The HAN Project was aimed at developing strategic industrial technologies in order to make Korea more self-reliant in science and technology (S&T). The HAN Project was broadly composed of two categories:

1. Product technology development focused on technologies that develop specific products, particularly high-tech products in which Korea had potential to compete with the advanced countries by the early 21st century. They were new agro-chemicals, ISDN, HDTV, ASIC, flat panel displays, bio-medicals, micro-machine, next-generation vehicles, and express railways;
2. Fundamental technology development emphasized core technologies that were indispensable for continued economic growth and high quality of life, e.g. next-generation semiconductors, advanced materials, advanced manufacturing systems, new functional biomaterials, environment technology, new energy, next-generation nuclear reactors, advanced super conduction TOKAMAK, and human sensibility ergonomics (Ministry of Science and Technology of the Republic of Korea, 2003. National R&D program in Republic of Korea. Retrieved from http://www.most.go.kr/).

This project was developed for the period of 1992-2001 years, as a large-scale inter-ministerial R&D project under co-funding mechanism between government and business sector (the total amount of funding for project was about $3.2 billion) (Ministry of Science and Technology of the Republic of Korea, 2003. National R&D program in Republic of Korea. Retrieved from http://www.most.go.kr/). This initiative was designed to promote joint R&D with participation of universities, companies from various sectors of the economy and public research institutions. The HAN project was not limited to the anticipation of possible futures but to elaboration of concrete measures and designing of initiatives to respond to the identified challenges, problems and long-term needs.

The HAN project represented a shared vision of six ministries about the path of national R&D development in South Korea. Implementation of the foresight outputs into the policy-planning process allows Korea to make a transition from vertically oriented S&T management system to horizontal system [17].

Foresight exercises conducted in South Korea helped to improve communications between public institutions involved in the strategic planning process. It provided a clear identification of the priorities for the future technological development and estimated budget for the National R&D programs. Development of expert networks and establishment of the National Science and Technology Information System (NTIS) allowed gathering decentralized S&T information for the decision-making process. It also helped to build a consensus among all key actors and increase the number of joint R&D projects, especially in terms of interactions between science and industry.

3. National foresight in Kazakhstan

3.1 Scope and Design of the National Foresight in Kazakhstan

To identify National STI priorities in Kazakhstan 2 National Science and Technology (S&T) Foresights were conducted.

The First National S&T Foresight had a time horizon until 2020 year and was hold in 2011-2012 years under the initiative of the Ministry of Investments and Development of the Republic of Kazakhstan (MOID). The First Foresight produced the list of strategic technologies (75 key technologies in 8 priority sectors). The following actions were conducted for the implementation of foresight outputs in Kazakhstan:

- based on the foresight results the Government of Kazakhstan approved priorities for allocation of innovation grants;
- in the period of 2013-2014 years, innovation grants provided by the MOID in compliance with the list of strategic technologies resulted from the First National S&T Foresight;
- to support the development of strategic technologies MOID had also launched an initiative to set up Targeted Technology Programs with an aim to mobilize all stakeholders and increase cooperation between science and industry. Targeted Technology Programs were designed based on the results of the foresight in the format of the “Triple Helix Model” which requires government- science-industry collaboration.

In 2013-1014 years the Second S&T Foresight "System analysis and S&T Foresight" was initiated by the Ministry of Education and Science of the Republic of Kazakhstan (MES). Time horizon of the foresight was set up until 2030 year. The main purpose was to identify key products and services, promising technologies and R&D topics that could become engines for the rapid economic growth and could be considered as a basis for a long-term research and innovation development. Identification of priority areas for S&T development in Kazakhstan was based on the assessment of socio-economic impact of promising technologies, as well as assessment of resources and technological capacities of the country.

The Second Foresight was aimed at providing a framework for strategic thinking process on the possible options for STI development in Kazakhstan based on identification of key trends, opportunities and risks, as well as on the assessment of existing competencies in the world and in the Republic of Kazakhstan.

4. Methodology

Methodology for the National foresight exercises in Kazakhstan was designed in cooperation with the Korea Institute of Science and Technology Evaluation and Planning (KISTEP). Methodology applied for the Second National S&T foresight included such methods as: expert panels; analysis of future trends, needs and opportunities for S&T development; patent and bibliometric analysis; STEEPV analysis; analysis of acting STI policies and programs; analysis of domestic competencies and resources; scenario writing exercises; expert surveys (including experts from industry, research institutions and academy); technology analysis; identification of key products and services, strategic technologies and key R&D topics; roadmapping activities.

Expert panels consisted of the leading experts in eight strategic sectors: National Health; Secure, Clean and Efficient Energy; Biotechnology; New Materials; Environment and Natural Resources; Mechanical Engineering; Information and Communication Technologies; Sustainable development of Agriculture. To achieve consensus between all stakeholders (research, academia, industry, public bodies) results of the Foresight were discussed on the roundtables and seminars and posted on the organizer's website.

Activities of expert groups were aimed at provision of basics for strategic understanding of the options of further development consistent with key trends, factors and possible risks. The works performed were based on generation of scenario for development of science and technologies in Kazakhstan. Experts' work included the analysis of scientific and technical information, analytical reviews of leading national and international research organizations, analytical reviews of industrial development, bibliometric and patent analysis.

The second S&T Foresight provided a framework for integration of industrial and STI policies by identification of key products and services for the country and linking them with strategic technologies, which should be developed in Kazakhstan. The same logic was implied for identification of key R&D topics. Key R&D topics were identified in compliance with strategic technologies that are needed to produce key products and services.

List of key R&D topics was used in the planning process as a basis for roadmapping activities. Implementation of the roadmaps was suggested to be split into separate stages: operational plan (until 2018), strategic plan (until 2020) and long-term vision (until 2030). Special performance indicators were defined at each stage of the roadmap. Afterward, cross-sectoral discussions of expert groups were initiated to identify interdisciplinary crosscutting research topics. Cross-sectoral meetings resulted in interdisciplinary National R&D Programs. This approach allowed determination of new technological solutions on the intersection of the adjacent scientific areas.

5. Discussion

As the examples of South Korea, Singapore and Kazakhstan show, integration of foresight results into the policy-planning process is important and ensure transparency through the engagement of all interested parties. In addition, foresight raises awareness of participants about possible directions of STI development in the future, risks they may face and opportunities that should not be missed. The same time incorporation of foresight into policy planning ensures higher level of their commitment to proposed policies and strategies.

Participation in foresight representatives from industry, science, government enables to raise the level of mutual understanding among key stakeholders and ensure more comprehensive and interdisciplinary nature of work. Involvement in national foresight exercises all main stakeholders will help to ensure their commitment to policies and strategies elaborated on the results of foresight.

Activities conducted during foresight exercise can be divided into two categories: future study (investigation and anticipation) and foresight. Future study allows considering and analyzing possible, probable, plausible and preferable options of future. Foresight aims at building consensus between different actors and elaboration of recommendations, policies and strategies based on the results obtained at the stage of future study. Foresight helps decision-makers to investigate possible alternatives by thinking beyond the ordinary perception of reality. A high level of uncertainty and variety of alternatives require involvement of all stakeholders into strategic planning process.

Fig. 1. Interests of different actors in the results of foresight

Foresight allows anticipating future needs and possible changes and elaboration a set of actions and strategies to cope with future challenges. Results of the national foresight can be effectively used for the development of long-term policies and strategies and should be disseminated among the society. To increase the effectiveness of the strategic planning process the results of foresight should be disseminated among all institutions responsible for implementation of STI policy in the country. Marc K. Peter and Denise G. Jarratt claim that integration of foresight knowledge into an accessible platform for all stakeholders and most important for top decision-makers is an important element of foresight integrated long-term planning process (Marc K. Peter, Denise G. Jarratt, 2015).

A high degree of decentralization and fragmentation of information databases negatively affects strategic planning process and S&T policy management in Kazakhstan. The lack of the dialogue and coordination between ministries, eventually, leads to a low efficiency of implemented programs and projects. As experience of South Korea and Singapore shows, national S&T foresight can be used as a platform for coordination of inter-ministerial strategies and programs in Kazakhstan.

The results of foresight can be used for the development of long-term and medium-term policies and strategies as well as short-term plans and programs (less than 5 years). Foresight findings should be incorporated into the process of policies and strategies elaboration to ensure the greater cooperation across the innovation system [18].

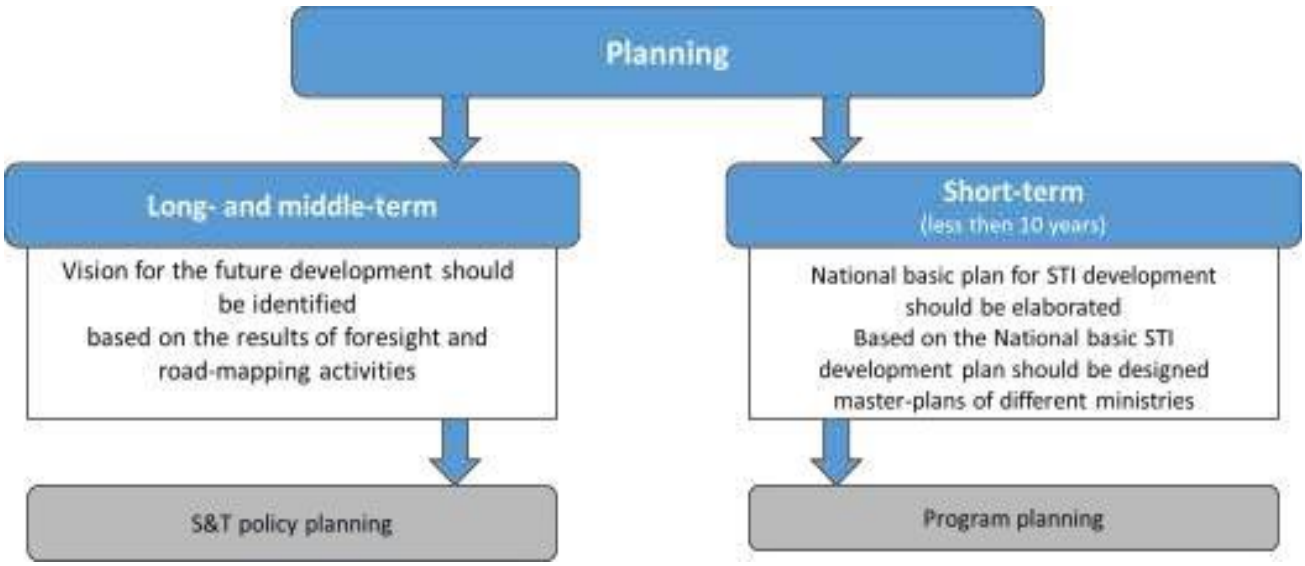

Fig. 2. National S&T planning process

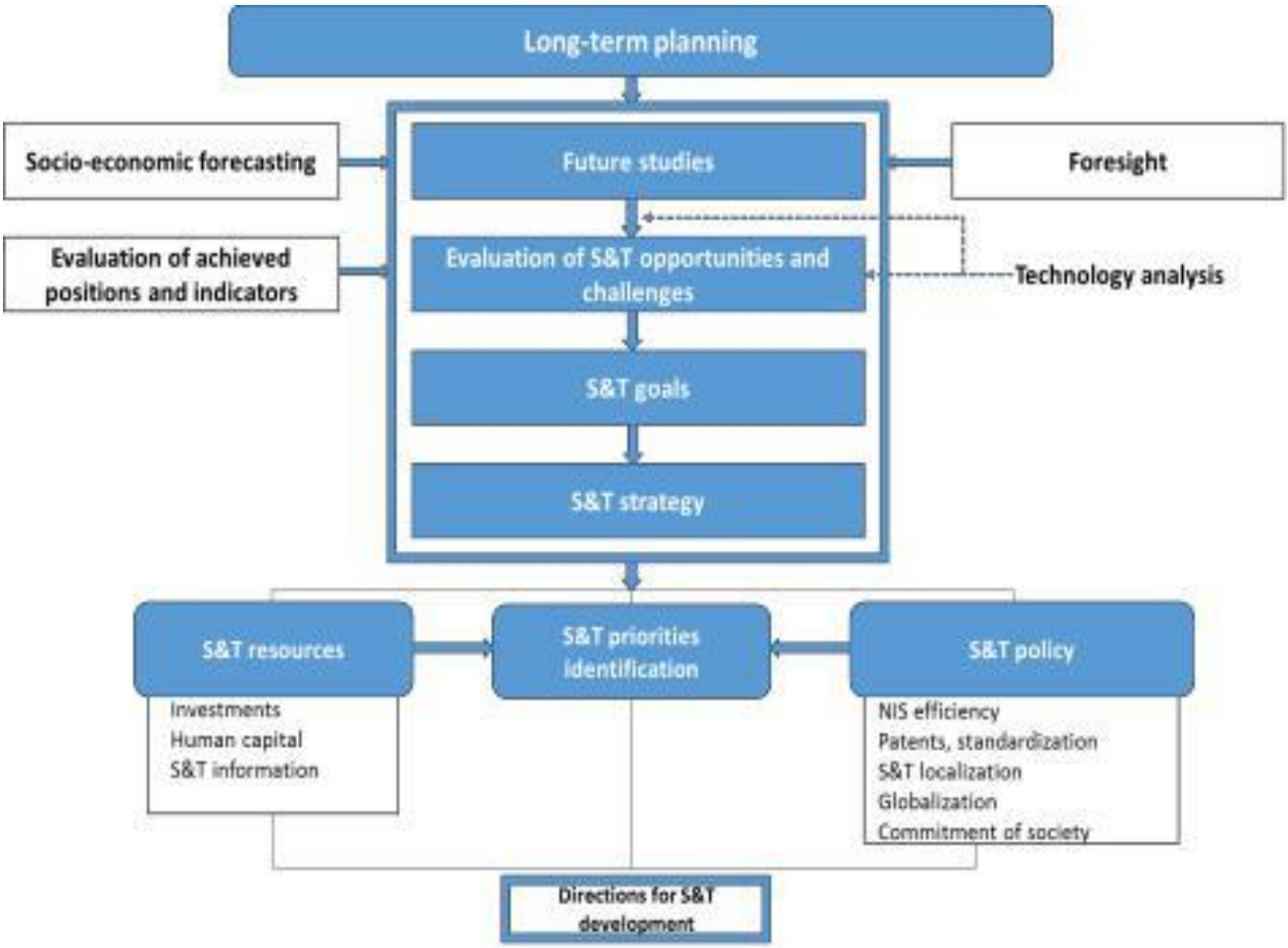

Fig. 3. S&T policy planning

Based on the experience of South Korea we can propose the following framework for the long-term planning that includes elaboration of STI development strategy (vision of STI development) based on the results of scenario planning, priority setting and roadmapping activities. National S&T Plan should be elaborated in consistence with a long-term vision of STI development. Master plans of ministries and agencies should be designed according to the National S&T Plan.

Strategic areas for S&T development should be identified based on the foresight results. Insertion of foresight results into the National S&T Plan will ensure better commitment of all interested parties in implementation of proposed actions. To fulfill strategic tasks, national R&D programs should be designed.

National R&D programs include specific R&D projects aimed to develop strategic technologies. The portfolio of national R&D programs and projects should have a problem-oriented nature.
Different ministries can implement national R&D programs, but it is necessary to avoid a duplication of investments. This issue can be resolved by means of effective system of national R&D management and coordination. Fig. 5 shows inter-ministerial process of National R&D programs development. This approach helps to eliminate duplication of government investments in S&T based on inter-ministerial coordination of National R&D programs in accordance with the National S&T Plan.

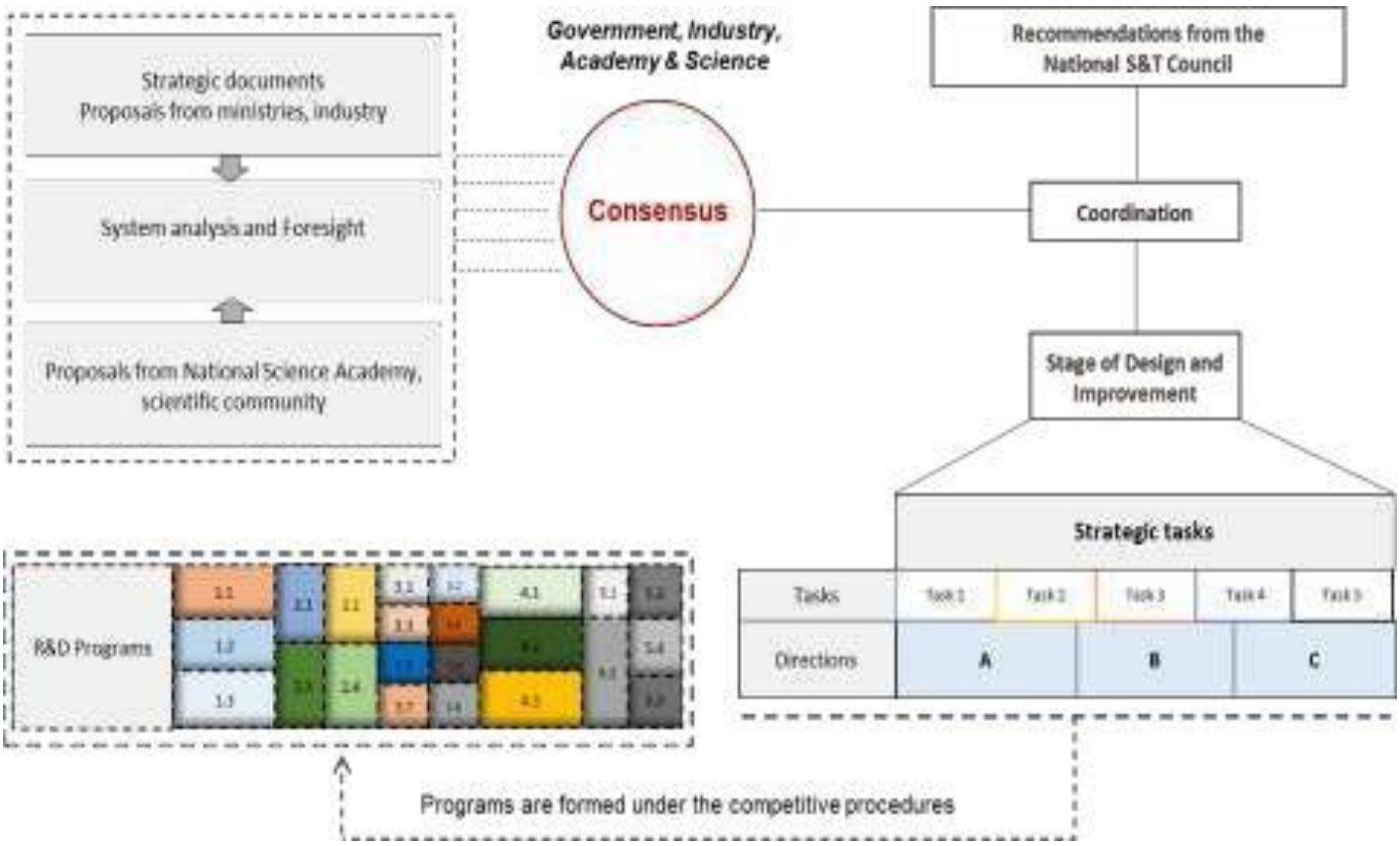

Fig. 4. S&T priorities setting on the national level

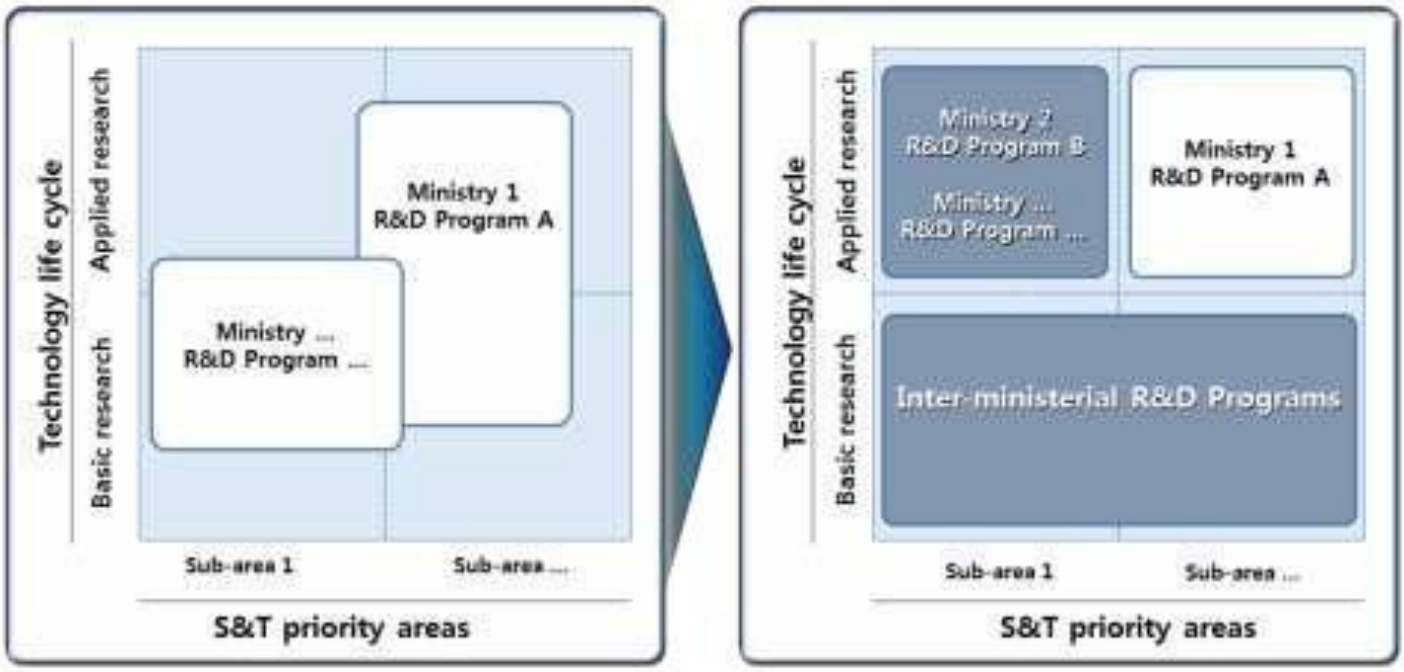

Fig. 5. Process of national R&D programs development on the country level

Different ministries and agencies are engaged in the management of STI development on various stages of R&D process (from the stage of basic science to the stage of commercialization). All these ministries and agencies should maintain an internal coherence of S&T master plans, R&D programs and projects to the main goals of the National STI policies and strategies.

For example, the National S&T Basic Plan in South Korea is designed based on the results of the National foresight exercise. National S&T Basic Plan sets national S&T priorities and master plans of different ministries are designed in accordance to the National S&T Basic Plan. National R&D programs are designed with an aim to develop key technologies identified by the National foresight exercise. National R&D programs consist of specific R&D projects. Development and monitoring of such projects is carried out by sectoral ministries with involvement of highly qualified experts who might be representatives of interested business, scientific and academic community. Ministries that involved in STI management process are responsible for R&D roadmapping activities. R&D roadmaps are designed to improve strategic capabilities and efficiency of public R&D investments from a long-term perspective. To consolidate all roadmapping efforts on the country level and to provide a unified direction to all medium-term public research programs a single R&D Total Roadmap was designed in 2006. R&D Total Roadmap included medium and long-term R&D strategies for public R&D investment portfolios. This allows to improve coordination and coherence among different ministries and agencies that involved in R&D planning and STI policy implementation [19].

National R&D programs are diversified and belong to different sectors. The whole process of strategic planning on the national level should be based on principles of planning-implementation-evaluation and inter-sectoral coordination to prevent duplication of public investments in R&D.
National R&D Programs can be implemented as a part of the Technology Platforms development. Technology Platforms (further - TP) are based on the common vision of scientific and technological development and common approaches for the development of key technologies.

According to the internationally accepted definition, the TP are objects of innovative infrastructure that allow effective communication and the creation of promising advanced technologies, high-tech, innovative and competitive products based on the participation of all interested parties (government, industry, science, education, public organizations). In the EU, technology platforms are a demand-driven innovation policy tool [20].

TP can be formed on the basis of the results of foresight studies, taking into account the importance of the sector (direction) in terms of implementing the priorities of the country's socio-economic development, for solving such problems as:

1) Linking needs of business and society with implementation of the most important areas of scientific and technological development;
2) Identification of new scientific and technological opportunities for the modernization of existing sectors and the formation of new sectors of the Russian economy;
3) Determination of the principal directions for improving industry regulation for the rapid spread of promising technologies;
4) Stimulation of innovation, support of scientific and technical activities and processes of modernization of enterprises, taking into account the specifics and options for the development of industries and sectors of the economy;
5) Expansion of scientific and industrial collaboration and the formation of public partnerships in the innovation sphere;
6) Improvement of legal regulation in the field of STI development.

6. Conclusion

This paper contributes to understanding of the theoretical aspects of foresight integration into STI policy planning and provides practical recommendations on structural composition of future policy planning based on the foresight. Practical recommendations include the framework for STI policy planning based on the foresight results.

Based on the literature review and analysis experience of different countries in implementation of foresight results into future policy planning, we came to conclusion that to make the process of STI policy planning more effective all stakeholders have to come to a common understanding of key issues and share a common vision of the future. In publications in the section of literature review above we found that greater attention is paid to exploring of methods, tools and practical implementation of the foresight, however issues related to understanding of mechanisms for integration of the outputs of foresight into future policy planning has been limited. In this regard our research comprises practical recommendations on setting up an efficient STI policy planning based on foresight results.

Foresight results as a mutually agreed vision of the future should be incorporated into the process of STI policy planning. It will ensure commitment of various ministries and agencies to the proposed policies and strategies and ensure that implementation of the strategic plan is jointly undertaken by all actor groups.

The experience of Singapore, South Korea and the Republic of Kazakhstan proves that to ensure greater efficiency of national S&T foresight it should be integrated into STI policy planning.

Kazakhstan as a developing country has faced with several problems related to the fragmentation of national innovation system, weak links between institutions involved in STI policy implementation, problems in S&T priorities identification and evaluation of the efficiency of implemented strategies and programs. In this regard, national foresight can be considered as a tool for mobilization of all main stakeholders and building of mutual consensus and commitment to the proposed policy and strategies.

Problems in implementation of policies and strategies often relates to the lack of stakeholders commitment to act according to the approved policies and strategies. In this regard foresight should be focused on "action" and should be linked to the decision-making system [21]. To ensure greater efficiency the national strategic planning process should be based on the following principles:

1) Focus on improving the competitive advantage of the country;
2) Planning process should be transparent, unbiased, and objective;
3) Planning process should be based on active participation of all stakeholders;
4) Highly qualified and competent experts should be involved in the planning process; and
5) Policies and programs should contain plan of actions including schedule, resources required for implementation, participants, milestones, target indicators, etc.

In foresight exercises, issues related to sharing and implementation of foresight results shouldn't be underestimated. Organizers of foresight should clearly identify who will be the main "client" and will take a responsibility to implement obtained results.
Based on the experience of South Korea and Kazakhstan in implementation of foresight projects the following ways of enhancing an effectiveness of national foresight exercises can be recommended:
Iin foresight exercises, issues related to sharing and implementation of foresight results shouldn't be underestimated. Organizers of foresight should clearly identify who will be the main "client" and will take a responsibility to implement obtained results.

Based on the experience of South Korea and Kazakhstan in implementation of foresight projects the following ways of enhancing an effectiveness of national foresight exercises can be recommended:

- dissemination of the main ideas and techniques of foresight among the expert community, highlighting advantages and opportunities offered by conducting foresight exercises. It will help to develop competences in the field of foresight and to improve the culture of strategic planning in the country;

- i nvolvement of all stakeholders (including government institutions, academic, scientific and business community) in foresight and planning activities. Development of expert network will provide an integrated and interdisciplinary nature of work. In addition, active participation of all major actors in foresight exercises will ensure greater transparency, better understanding, acceptance and commitment to the results. It will also help to improve the efficiency of integration of the foresight results into strategic planning process;

- interdisciplinary approach to expert groups composition;

- ensuring inter-ministerial collaboration at all stages (at the stage of foresight exercises and at the stages of planning and implementation of obtained results) to ensure information sharing, transparency, equal consideration of different stakeholders positions and opinions, consistency of policies and programs and commitment to their implementation;

- alignments of S&T master plans of different ministries horizontally and vertically with the national S&T plan based with the results of the national S&T foresight. To improve STI policy coherence two main aspects of STI management should be considered: 1) horizontal coordination of STI policies across different ministries and 2) vertical coordination of governance arrangements related to research and R&D commercialization. Policies and programs should have overall coherence otherwise there is a risk of their ineffective implementation.

- targeted dissemination of foresight results among the society to create a shared vision concerning long-term developments within science, technology, innovation and society as a whole and to facilitate all interested parties to act accordingly to the designed policies and strategies.

Competing interests

Authors have declared that no competing interests exist.

References

[1]. Gokhberg L, Meissner D, Sokolov A. Foresight: turning challenges into opportunities. In Deploying Foresight for Policy and Strategy Makers 2016;1-8. Springer, Cham.

[2]. Miles I. The development of technology foresight: A review. Technological Forecasting and Social Change. 2010;77(9):1448-56.

[3]. Vishnevskiy K, Karasev O. Challenges and opportunities for corporate foresight. In Deploying Foresight for Policy and Strategy Makers 2016;65-79. Springer, Cham.

[4]. Martin BR. The origins of the concept of 'foresight' in science and technology: An insider's perspective. Technology Forecasting and Social Change. 2010;77(9):1438-1447.

[5]. L, Keenan M. Evaluation of national foresight activities: Assessing rationale, process and impact. Technological Forecasting and Social Change. 2006;73(7):761–777.

[6]. UNIDO. Technology Foresight Manual. United Nations Industrial Development Organization. Vienna. 2005;1.

[7]. Na Li, Kaihua Chen, Mingting Kou. Technology foresight in China: Academic studies, governmental practices and policy applications. Technological Forecasting and Social Change. 2017;119:246-255.

[8]. Weigand K, Flanagan Th, Dye K, Jones P. Collaborative foresight: Complementing long-horizon strategic planning. Technological Forecasting and Social Change. 2014;85:134-152.

[9]. Sutherland WJ, Woodroof HJ, The need for environmental horizon scanning. Trends in Ecology and Evolution. 2009;24(10):523-527.

[10]. Vecchiato R. Creating value through foresight: First mover advantages and strategic agility. Technological Forecasting and Social Change. 2015;101:25-36.

[11]. Integration of foresight into science, technology and innovation policy planning. *Shevchenko E.V., Pomogaev V.M., Stukach V.F., Tretiak V.P.*/Innovation Management and education Excellence through Vision 2020. Proceedings of the 31st International Business Information Management Association Conference (IBIMA). 2018. С. 3264-3277.

[12]. Rhisiarta M, Millerb R, Brooks S. Learning to use the future: Developing foresight capabilities through scenario processes. Technology Forecasting and Social Change. 2015;101:124-133.

[13]. Habegger B. Horizon scanning in government. Concept, country experiences, and models for Switzerland. 2009;17-20.

[14]. How Khee Yin. Singapore's risk assessment and horizon scanning project: an update. International Risk Assessment and Horizon Scanning Symposium, 19-20 March, 2007, Singapore, 6. Kim, L. 2000. The Dynamics of Technological Learning in Industrialization. The United Nations University INTECH, Discussion paper series. 2007;200(7):22.

[15]. Habegger B. Strategic Foresight in Public Policy: Reviewing the Experiences of the UK, Singapore, and the Netherlands. Futures. 2010;42:49-58.

[16]. Andersen AD, Andersen PD. Foresighting for inclusive development. Technological Forecasting and Social Change. 2017;119:227-236.

[17]. Kim L. The Dynamics of Technological Learning in Industrialization. The United Nations University INTECH, Discussion Paper Series. 2000;200(7):22.

[18]. EFMN. European Commission, European Foresight Monitoring Network - Mapping Foresight – Revealing how Europe and other Words Regions Navigate into the Future. 2009;10-15.

[19]. OECD. OECD Reviews of Innovation Policy: Korea, Paris. 2009;178–194.

[20]. Rudnik PB. Technological platforms in the practice of Russian innovation policy. Foresight. 2011;5(1):16-25.

[21]. Schlossstein D Park. Comparing recent technology foresight studies in Korea and China: towards foresight-minded governments? Foresight. 2006;8(6):48-70.