SPIEF'16

ST. PETERSBURG INTERNATIONAL ECONOMIC FORUM

JUNE 16, 2016

PANEL SESSION

THE BIG CHALLENGES IN PROMOTING SCIENTIFIC DEVELOPMENT

THE PROGRAM WAS DEVELOPED WITH THE PARTICIPATION OF EXPERTS FROM THE NATIONAL RESEARCH INSTITUTE, PRIMAKOV INSTITUTE OF WORLD ECONOMY AND INTERNATIONAL RELATIONS (IMEMO), RUSSIAN ACADEMY OF SCIENCES

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Content

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Introduction. Big Challenges as new reality

Big Challenges (also known as "Grand Challenges") as a combination of problems, risks and opportunities, important factors and long-term trends will determine the future of world economy and politics, global agenda and development of different nations and regions for the decades to come. There are number of such Big Challenges, including but not limited to:

– **Anthropogenic impact on the environment,** which poses great socio-economic risks and even threatens people's life and health. Rise of sea level; water, soil and air pollution (air pollution in the cities increased by 8% globally in recent years); droughts and other natural disasters are reality to be considered here and now.

– **New demographic and epidemiological transitions** such as population ageing in developed and advanced developing nations, emergence of new social problems related to this process; rising scales of chronic diseases and pandemic threats.

– **Social stratification** both at the domestic level and at a global scale, where it acquires prominent regional character, causing migration and regional conflicts.

– **Underperformance and diminishing controllability of complex socio-technical systems,** especially critical infrastructures (transport, energy, financial, etc.). Their scale, complexity and environmental impacts create significant risks, while technical infrastructures are reaching natural limits of modernization and optimization ability, because the potential for development of their generic technologies is almost exhausted.

Due to its universality, the concept of Big Challenges has been spread among all major world powers, it is reflected in different ways in long-term strategies and policies of the European Union, the United States of America, China, India, Brazil.

Big Challenges are accompanied with sophisticated palette of national problems. As example, in Russia one of this is spatial factor, which determines specific character of logistics, regional connectivity and resources allocation.

Solutions for the Big Challenges can`t be found within existing development paradigm: natural, financial and human resources of entire planet are not enough for this. This "unresolvable" contradiction can only be dismissed by science, technology and innovation, which are able to provide ingenious solutions, including ones that are not directly connected with the challenges faced nowadays.

I. How science is changing?

From the formal point of view, global science and technology sector have all needed capacities to respond to Big Challenges. In 2015 global expenditures on research and development (R&D) reached $1.9 trillion (PPP based). R&D were steadily increasing during last decades and there is no reason to believe that this trend will change in the foreseeable future.

The USA, the EU, Japan and other developed nations accent increase in R&D intensity and scientific and innovative performance of their economies. **Emerging economies, particularly the BRICS nations and Iran, also set ambitious goals in science and technology.** China plans to increase its R&D intensity up to 2,5% of GDP by 2020. The number of patents and scientific papers is increasing as well.

However, the key issue is not in mechanical increase of R&D or rise of other quantitative indicators. Such approach will not lead to the breakthrough. **So the effective solution could be found only by reorganization of the whole system of science, technology and innovation support, institutional changes, and by formation of new management mechanisms.**

Organizational models of science and technology activities always reflected requirements of economy and dominant production method. Powerful manufacturing, especially mechanical engineering in the end of 19th –the middle of 20th century required formation of duopoly of large scientific research centers and technological corporations. Electronic industry, first period of information technologies (IT) and biotechnology development brought to life mass segment of small innovation businesses. Further development of IT and innovations in service sector and consumer goods during 2000-2010s resulted in rising involvement of individual innovators or their teams ("open" and network innovations, crowdsourcing).

However, **old organizational forms never vanished, but evolve**: for example, universities changed their identity from research university model of industrial era to entrepreneurial university of IT/biotech period.

Should new organizational models in science, technology and innovation arise in response to Big Challenges – and if so, how they should look like?

The potential of "small" forms, typical for biotech or IT, or networks are not enough. But **whether the old system of big actors will fit new challenges?** Historically, such major centers as the USSR Academy of Sciences, US National laboratories and leading US and European universities, corporate mega-labs (such as Bell labs) have obtained results so significant that we still use them (for example, the Internet, Earth's remote sensing or lasers).

The results were achieved due to the concentration of enormous intellectual and financial resources. However, it is unlikely to repeat this experience nowadays: the ability of nation states and corporations to mobilize and focus resources is much lower, while the requirements for management flexibility due to the rising global competition are much higher. In addition, in the context of global and domestic mobility, it is difficult to attract scientists and inventors to the large semi-closed structures and, moreover, to make them work creatively and productively there. Finally, science and technology more and more requires openness, at least in terms of exchange of ideas; connection with peers; search for complementary knowledge, competencies and solutions.

Science itself is also changing. Rigid division between basic and applied research and technological activities in many spheres (information technologies, biotech, material science, etc.) is now irrelevant and ineffective. **The focus is on the interdisciplinary research, with gradual shift towards knowledge convergence**, suggesting completely new level of penetration and synergy between different disciplines and methods. This is particularly true for the promising directions of R&D like "smart energy" area, where information sciences, energy research, mathematics, sociology and even psychology are utilized. At the same time, **modern science requires interfaces with real life and practice**. A special I-Corps program of the US National Science Foundation is indicative in this case, being aimed at the development of entrepreneurship skills among scientists.

To address abovementioned and other related issues innovation leaders use various approaches, encouraging creation of broad collaborations, forming networks, support the training of new type specialists. However there is no universal solution, which is demonstrated by the continuing experiments with the forms and methods of R&D and innovation management.

Obviously, the changes will affect the universities and science and technology organizations, the process of research, the culture and science, technology and innovation institutions. The specific important task is to support effectively new architecture of science without ruining successfully functioning structures.

QUESTIONS for DISCUSSION:

– Envisioned transformations of science and technology and related national policies – is it a new Big Challenge?

– What organizational models should appear in science and technology area to respond to Big Challenges? What shall be done to develop new models without disrupting existing effective institutions of science?

– Should Russia prioritize formation of advanced science, technology and innovation models – or as a first step it is necessary to create efficient institutes, typical for stages already passed by the most developed nations?

II. Key motives of science discovery and approaches to stimulate science development - what are they?

Inspite of the fact, that organization of science always reflected dominant socio-economic system, real motives of science discoveries were different. At large it could be split into two categories:

– solutions of practical tasks ("external" factors);

– curiosity-driven research as key value of scientific discovery ("internal" logic).

Its balance has always been different, but disruptive results occurred when state ensured harmonization of these motives.

In case of Russia, combination of global and national challenges result in imperative of science and technology development – especially since other resources of development are depleted or are very limited in volume and scope.

It's to be recalled, that Russia share in the global GDP (PPP based) is less than 3,3%, in the world export of high-tech products – near 0,5%, in global R&D expenditures – less, than 1%. **Profits from raw materials export as source of investments in science and technology development are no more an option** – due to long-term global price decline for hydrocarbons and metals.

Russian human capital advantages aren't endless and, by the way, are specific (excellence in a limited areas of natural sciences, inefficient ties of science and practice, low orientation on society, market and consumer`s needs and interests).

Due to the scale and complexity of arising challenges, ambiguity of possible solutions, there are different ways of how science, technology and innovation may respond to them. Each of these options has its rational basis and specific set of interests of engaged subjects.

1. **Focus on curiosity-driven basic research – for radically new responses for Big Challenges.** There are multiple cases in history, when great scientific discoveries result in solutions for serious socioeconomic problems: from semi-conductors and informational technologies to "green" revolution in agriculture.

This approach presumes use of Big Challenges as guidelines for scientific research. But **"internal" logic and mechanisms of science development become dominant** (focus on research quality as key value, down-top curiosity-driven formation of research topics – as a guarantee of formation of prospective scientific areas, etc.). Theoretically, using this approach we can get important and valuable results in the long term, which could overcome all current barriers and create brand new markets and possibilities – but by giving up some short-term benefits.

Nevertheless, skeptics and critics often point out, that this approach is overburdened by serious questions about guarantees that a truly disruptive results would be achieved – **in an acceptable for nation and society time frame, and about how to utilize created potential**.

2. **Concentration of efforts on given list of priorities** – efforts and resources of science, technologies and innovations should be focused on resolving bottlenecks of development of some key existing generic technologies, considered to be disruptive and oriented on specific global and national challenges.

Nowadays even the wealthiest and powerful economies face severe resource constraints. Growth of global competition and rising science and technology complexity exacerbate this problem. Consequently, both emerging economies and more developed nations are forced to chart their priorities in science, technology and innovation spheres clearly.

The stake is made on the areas, which can radically transform markets and life of people. In most cases new developments are based on already well-developed science and technology directions.

There is a global consensus about key development areas: most of the nations unified their official (fixed in the top level documents) and de-facto (i.e. realized in national R&D budgets, preferences of researchers – as reaction on state and private sector expenditures) priority lists.

But this unification create new risks for development:

Firstly, as areas of competition match, competition of different nations for global leadership become more and more harsh.

Secondly, new risks arise of monopolizing leadership by countries with the biggest R&D investments. Emerging and less advanced economies often have to opt for technology import instead of development.

Thirdly, even considering high level of consensus about priority science and technology areas, nobody can be fully sure that offered generic technologies or solutions are best for responding to Big Challenges. Probably, a more fundamental breakthrough is needed – to reach a new level of technology development.

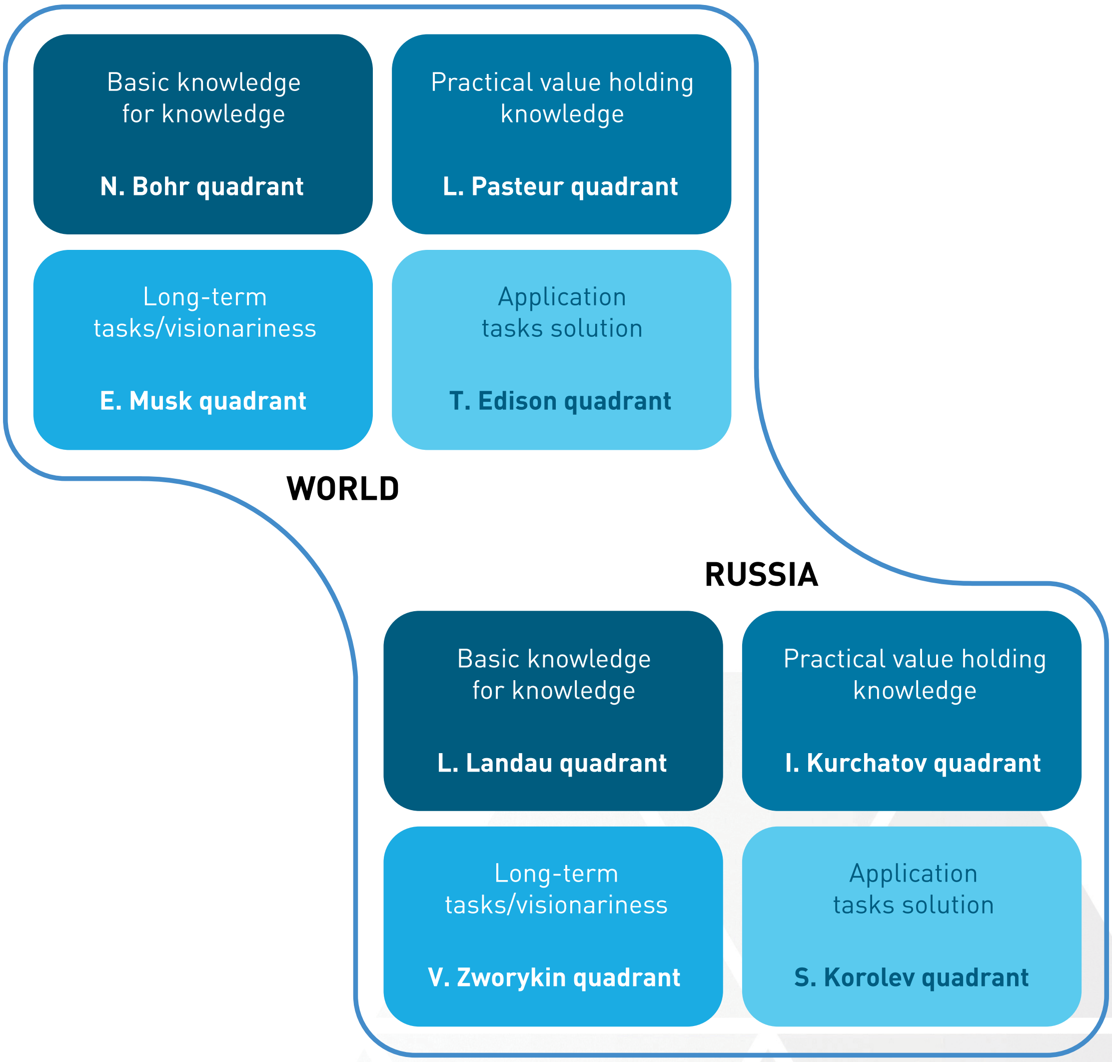
3. **Focus on human capital** including unique skills and knowledge, that also overcome barriers between different areas of science (interdisciplinary and multy-disciplinary competencies and approaches) and barriers between science and practice (technology entrepreneurs and visionaries).

This approach is **especially important considering transition from Knowledge-Driven Economy to Knowledge-Driven Society**, where human capital is the key resource and, at the same time, area of global competition. No wonder, that most developed nations compete for skilled specialists from all over the world. Leading position hold the USA, where 15-50% of researchers in key disciplines of science, and more than

50% of the Silicon Valley residents in some areas aren't Americans by birth. This high-skilled immigration is one of important factors US science and innovation leadership.

Human capital issue is especially important for Russia since it is well known for its talents potential. But more should be done for its reproduction and quality rise. On one hand, specialists with new skills and competences are needed, especially in areas with high growth potential – outside of traditional "domains" of Russian science (such as nuclear physics, mathematics, etc.). On the other hand, it is necessary to form a class of innovators and entrepreneurs, visionaries and science practitioners - persons able to convert knowledge to profit, maximize the share of value add produced in Russia, facilitate rise of quality of life and solve other problems.

Russia's problems and differences in its human capital development comparing with the leading nations are well seen on so-called Stocks diagram. Ambiguity and specifics of practice-oriented quadrant of Russian science (outside defense sector), as well as problems with visioners self-realization are obvious.



Picture 1. Modified D. Stokes diagram.

QUESTIONS for DISCUSSION:

– Do we need radical science breakthrough for answering Big Challenges - or we can use existing potential only modifying organizational models?

– Science and technology priorities and disruptive technologies: how one can triumph over leader economies on their own playing field?

– How to ensure growth of quality of human capital in Russia and unleash self-realization potential of technology entrepreneurs and innovation visionaries?

III. Key instruments of Science and Technology development

Complex answer on Big Challenges requires future radical changes in national policies. Three potential approaches and tools could be defined:

- **Direct support and promotion of science and technology actors or areas.** These measures are mostly relevant for catching-up economies, but its` adapted version is also used by developed nations to support disruptive innovations. The problems of this approach are so-called "government failures" (substitution of market and economic rationales by bureaucracy, governing structures are more sensitive to lobbyism, than to rational choice, etc.).

- **Improvement of institutions and support of economic inputs for innovations (labor, basic research, etc.).** This approach presumes that state takes the risks and expenditures, which are excessive or impossible for private sector, while granting businesses freedom of initiative – considering that this will improve efficiency of development. This approach is in general justified, but faces "market failures": business sector focuses primary on short-term and more profitable areas and technologies, rarely accenting advanced and revolutionizing solutions.

- **Support of cooperation, network formation and other interaction between actors.** This approach is used primarily developed nations. It supports synergies, which theoretically leads to new quality of development. At the same time this approach also suffers from several problems: its formalization is a great challenge, it is very complex in term of realization and needs extra-high quality management on the side of each party engaged – up to the full policy reconfiguration.

In practice neither of the approaches is used separately, there is a creative complementarity of different measures.

It is still unclear, which approach is best for Russia – and to what extent. Here we shall stress, that almost all of the possible innovation development instruments are present in Russia - from special investment funds to so-called Technology Platforms.

One of the possible solutions are "transit" institutions and instruments – which could possibly provide transfer from our Soviet and early post-Soviet past to advanced policies and organization models in science. Global practice shows, that similar approaches have positive results. Particularly, in China use of planned economy and dirigiste innovation policies helped to construct big successful high-tech businesses.

Identifying specific factors of leadership is of a key importance as well. This refers not only to human capital, investments or infrastructure. Historically, the greatest breaks were possible due to smart use of:

- unresolved or un-optimally supplied demand – at national or international markets (as example – disruptive growth of tablet PCs since 2010);

- cultural or institutional factors (for example, mass adoption of European advanced technologies in the USA in mid-to-late of XIX century due to enterprise culture; enthusiasm and ideology in USSR – for example, pride for motherland after 1961 Sputnik launch as the factor of aerospace area development);
- specificity of demand or demand and consumption culture (request to permanent upgrade of product lines in electronics and car industry in Japan, that stimulated development in these sectors; esteem of medicine as the factor of bio- and genetic companies rise in China);
- location and territory (Netherlands and Singapore – regional traffic hubs, capitalizing location also for high-tech, innovation, industrial and financial sectors development) and other factors.

Successful combination of science and technology achievements and use of these factors of leadership result in innovation growth and powerful socioeconomic returns.

It's important to emphasize that high-technology manufacturing or knowledge-intensive services are not always the key development areas. It's not uncommon that formally "traditional" or conservative industries experienced real economic revolutions driven by advanced technologies and innovations. Good example of that is the Unified Energy System of USSR-Russia, that embodies a wide range of creative solutions for large centralized energy sector, special automatics and other unique technologies, while granting significant positive effects for economy.

QUESTIONS for DISCUSSION:

– What approach could support formation of effective science, technology and innovation complex in Russia?

– Do we need "transit" institutions for success of national science and technology policy?

– How to transform Russia`s economic, socio- and infrastructure development imbalances, territorial, cultural and other specifics in leadership factors?

Conclusion. Beyond horizon: where is area of Russian leadership?

According to Big Challenges` logic and high expectations that we all put on science, technology and innovations, generally we are expecting more than just an acceptable solution for existing problems, but new quality of life and human development, overcoming of current barriers.

But what stands behind these expectations? Possibly, it is radical and full-scale socio-economic transformations, driven by new disruptive technologies, a radically new paradigm of development?

Or we should expect transformation of some selected industries or appearance of new ones – however, also changing structure of economy and human life? Many traditional sectors – from agriculture to retail – already start transition to new, high-technology platforms.

And above all, without reference to the rate of radicalness – where is Russia' place in these processes and what is its role in transformations of world economy and science?

QUESTIONS for DISCUSSION:

– Should Russia focus on most advanced high-technology and innovation areas, defined by leading nations as priority – to carve out a niche on future markets? Or, with regard to Big Challenges and country's specific features, breakthrough area will appear in different sectors (not necessary high-tech ones)?

– Considering historically powerful creative potential with unobvious experience of "mass products" creation, could Russia focus on a role of global supplier of unique solutions – and in this case how can Russia keep science and technology independence and reach leadership?

– Russia as a "factory of talents" and international platform for self-realization of human capital: do this concept has credibility as mainstream of science, technology and innovation development in Russia?

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