NATIONAL RESEARCH UNIVERSITY
HIGHER SCHOOL OF ECONOMICS

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LEADERSHIP AGENDA IN STRATEGIC S&T POLICY: A CROSS-COUNTRY COMPARISON

BASIC RESEARCH PROGRAM
WORKING PAPERS

SERIES: SCIENCE, TECHNOLOGY AND INNOVATION

WP BRP 112/STI/2020

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LEADERSHIP AGENDA IN STRATEGIC S&T POLICY: A CROSS-COUNTRY COMPARISON[3]

This paper represents a review of strategic level S&T policies in several leading (mostly OECD-member) countries. How are science and technology leadership being targeted and realized in most developed economies? What are the composition and drivers of such policies? How do the S&T policies and corresponding challenges transform over the last decade? These and some other questions constitute a discussion based on desk research comprising strategic documents, adopted in Germany, Sweden, China, Korea, and Japan. The outcomes provide certain S&T strategic options for further discussion, in terms of both, policy coordination and meeting the future challenges.

Keywords: science and technology, S&T policy, STI policy, STI strategy

JEL: O10, O25, O30, O38, O40, O50

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[3] The article is based on the study funded by the Basic Research Program of the National Research University Higher School of Economics (HSE) and by the Russian Academic Excellence Project '5-100'.

1. Introduction

Strategic level of S&T policy goes far beyond a routine science and technology governance; it ties mid- and long-term vision with available tools and opportunities, synchronizes various policy mixes in order to meet the general goals, and highlights the further development trajectories at various levels (Borrás and Edquist, 2013; Dutrénit and Crespi, 2014; Lanahan and Feldman 2015). At the same time, being a consistent part of an STI agenda, strategic S&T policies are generally expected to contribute to technological and industrial dimensions of economic development in quite simplistic and straightforward way, viz. in terms of GDP growth, entrepreneurial or trade, etc. (Autio and Rannikko, 2016; Schot and Steinmueller, 2019). In the mid-2010s OECD experts collected cases on national STI strategies and related targets (criteria) for the member countries, and this evidence confirmed the trend (OECD, 2014a). In order to declare a progressive economic development, governments specified the target indicators in relation with the current national situation, as well, as calibrated by estimated future values for the world or for a group of reference countries.

Today, facing the consequences of the "Corona-crisis", policy-makers try to reconsider the strategic dimension of S&T policies enabling more socially-oriented approaches, introduced just before the Covid-19 era (Paunov and Planes-Satorra, 2020; Estermann et al., 2020). This paper is based on comparison of S&T-leading countries in terms of targeting and achievement of similar goals. Its idea is to systematize the latest pre-Covid-19 trends in national S&T strategy mechanisms and provide an expert conclusion on their prospective development. The focus of the study is the structure of national S&T development strategies, features and content of the stated goals and objectives, approaches to formation and control of targets, and composition of policy instruments. The findings can be useful to consider while targeting S&T and STI strategic level policies and advancing research approaches of the same kind.

In terms of method this desk research is based on document analysis and applied to applied to select, decompose and systematize relevant policy documents. As an information base we collected a number of relevant official documents, devoted to national strategies and plans for mid- and long-term. They were formalized and structured by such parameters as duration periods, responsible bodies, goals, targets, applied mechanisms, ongoing outcomes etc. In parallel we compared the actual documents with the preceding ones to track changes in policies and also tried to relate the current statements with a broader social, economic, cultural and other context. This is a basic level approach, applied to disclose and compare general national trends, but it can be transformed further into a more complicated analysis, operating with global trends, like one, developed by IIASA/OECD (Hynes et al., 2020).

To study international practices, we selected countries that occupy the world-leading positions according to one or more S&T leadership criteria, and, at the same time, demonstrate relatively high quality of life of the population. The main selection criteria included gross expenditure on R&D (GERD) by PPP, GERD related to GDP, global share of high-tech commodity exports, GII position (Cornell University et al., 2019). The selected countries represented two macro-regions of the World (European and Asian ones). Table 1 summarizes strategic and policy documents selected for the analysis.

In terms of composition the analysis starts with a short general overview of the strategic documents and targets placed in the focus of the research. Then two aspects of S&T leadership policy are being discussed: S&T leadership policy coordination trends and new solutions in order to respond to emerging strategic challenges (except the Covid-19 crisis challenge which should be a topic for another, more focused study). This working paper, however, is positioned not as a deep focused research, aimed at complete solving of a particular research problem, but rather a problem-oriented review, developing general discussion in the subject field and setting up further questions.

2. Goal-setting and criteria for S&T and STI strategies

The common feature of the leading countries is absence of any targets or indicators related to relative leadership as such. In other words, strategic goals do not affect maintaining or improving leading positions among other economies; targets are not expressed in "world shares" or positions held by countries in international rankings. If governments declared goals, the achievement of which would strongly depend on the successes (or "weaknesses") of other countries (namely, "positional" goals related to the idea of leadership are characterized this way), such strategies could hardly be considered sovereign or optimal.

The goals of the "leaders" can be roughly divided into two categories:

— improvement of strategic characteristics for a certain (although not always strictly) period;

— transition of S&T sphere, economy, society to a new state (which is not necessarily formalized in quantitative terms).

Table 1 – Key documents determining the policy of S&T development and leadership in selected countries

Country	Main official documents	Duration
Germany	"Forschung und Innovation für die Menschen – Die Hightech-Strategie 2025" (BMBF, 2018)	2018-2025
Sweden	"Smart Industry – a Strategy for New Industrialisation for Sweden" (Government Offices of Sweden, 2016)	2016-…
	"Production 2030" (Teknikföretagen, 2020)	2017-2030
China	"China's 13th Five-Year Development Plan" (NDRC, 2016)	2016-2020
	"National Medium- and Long-Term Program for Science and Technology Development" (State Council of China, 2006)	2006-2020
	"Made in China 2025" (ISDP, 2018)	2015-2025
	Extendable target programmes «Spark», «Torch», «211», «863», «973», «985»	1986-…
Korea	"Future Vision until 2040" (MSIP, 2017)	2016-2040
	"4th Basic S&T Plan" (KISTEP, 2018)	2018-2022
	"4th S&T Development Plan for 2018" (MSIT, 2018, 2019)	2018-2019
Japan	"Future Vision 2030" (METI, 2017)	2018-2030
	"5th Basic S&T Plan" (Government of Japan, 2016)	2016-2021
	"Complex STI strategy for 2017" (Government of Japan, 2017)	2017-2018

Sources: https://www.hightech-strategie.de; https://www.government.se; https://produktion2030.se; http://en.ndrc.gov.cn; https://www.gov.cn; https://www.merics.org; http://www.innocom.gov.cn; http://www.most.gov.cn; http://old.moe.gov.cn; http://www.msip.go.kr; https://www.kistep.re.kr; https://www.meti.go.jp; https://www.cao.go.jp.

Strategic goals are formulated and detailed in different ways depending on state priorities, planning horizons, or degree of integration of programmes and projects. At the same time, three levels of goal-setting are clearly distinguished (Table 2):

— improvements and shifts in S&T;

— mid- and long-term systemic effects for the economy;

— long-term effects for society, environment, well-being of future generations.

The immediate growth in S&T, in the most generalized form, is expressed by GERD increase, or growing GERD share in GDP (less typically). Being fairly simple, generalized, and transparent, the GERD measure is laid at the basis of most strategies. Other possible indicators can include R&D personnel (or researchers only) headcount, as well as publication and patent activity. The listed indicators reflect the key R&D inputs and outputs (and, respectively, the S&T policy effectiveness) quite adequately in general. In particular countries where the problem of imbalances between basic and applied research (South Korea, Japan) is admitted to be of importance, respective criteria (e.g. achievement of a certain level of public funding for basic research) are also applied as an element of regulation.

Table 2 – Strategic level guidelines and targets for S&T policies in selected countries: general types and forms

Country	Types of strategic level indicators*							
	GERD level; share of GERD in GDP	Quality and scales of basic research development	Human capital of S&T (employment, mobility)	R&D performance (bibliometrics, patentometrics)	Efficiency of economy, labor productivity	Investment activity	Energy saving, reduction of environment pollution	Duration and quality of life, reduction of inequality
Germany	N							
Sweden	N				Q	Q		
China	N			N			Q	Q
Korea	N	N	N+Q			Q	Q	Q
Japan		N+Q	N+Q		Q			Q

* «N» – numeric indicators; «Q» – qualitative / composite indicators

An important, and possibly a key feature of S&T leadership policy is that its strategic goals go far beyond changes in the R&D sector. For instance, it addresses to benchmarks (quantitative and qualitative) reflecting socio-economic effects quite often. They typically include production efficiency and labor productivity, green technologies development, various kinds of socio-demographic improvement measures. Such indicators can take the form of complex indices based on quantitative and qualitative evaluation or peer review.

It is also to note, that the generalized strategic target indicators are not being used as criteria for achieving or missing the goals, but rather as an evidence of relationship between achievement of particular strategic goals and observed or expected large-scale and structural shifts. However, technically they can be used to monitor the interim progress of strategic policies. At the programme- and project levels, dozens of specialized short- and medium-term indicators and benchmarks can be applied (and in this case their achievement, as a rule, is mandatory).

3. Emerging challenges and solutions for S&T leadership policy

Quantitative criteria that directly indicate leadership or relatively high position among other countries typically are not included in S&T strategies in industrially-developed economies. Obviously, such a connection could be sought in the content of declared and realized policies reacting to general challenges, or emphasizing them. Practical challenges are often related with readjusting S&T policy mix in accordance with new governance paradigms (Table 3), since the latter are being regularly updated for new strategic periods.

Table 3 – Trends in STI leadership policy coordination

Practical challenges	**Governance paradigm choice**	**Solutions**		**Germany**	**Sweden**	**China**	**Korea**	**Japan**
Rigidity of generalized long-term strategies vs. inconsistency of integrated programmes	Sustainable evolution along a general vector vs. fast breakthroughs in selected directions; solving problems as they become available	Direct link between strategies and programmes, while programes can be "inherited" and last significantly longer than the strategies		+	+	+	+	+
		Rigid hierarchical configuration "long-term vision + five-year plan + annual plan"				+	+	+
		Absence (or framework-style) of a single "central" S&T leadership strategy				+		
Fuzzy generalizing guidelines and incompleteness of specific targets	Attention to the dynamic reference points of the "desired future" vs raising thresholds in the standard set of indicators	Formation of guidelines and priorities for more than 10 years on the basis of large-scale foresight research ("future vision")		+	+		+	+
		Option	Focus on constantly significant general guidelines	+		+		
			Diversification and updating of the reference system related to current economically- and socially-significant problems		+		+	+
Divergence between the official vision of leadership and the real situation in particular sectors and fields	Systemic realization of STI policy mix involving a complex evidence base and an effective public discussion	Definitely interdepartmental nature of S&T and STI policies				+	+	+
		Integration of modernization plans, policy mechanisms and regulation at strategic level					+	+
		Enabling of public interaction tools for all levels and mechanisms of S&T policy - media resources, communication platforms, demo projects, etc.		+	+		+	
Risk of global lagging behind due to ineffective international dialogue	Active involvement in shaping the global agenda for the future	Formally declared accession to international framework initiatives and standards (at the level of the OECD, the EU, etc.)		+	+	+	+	+
		Large international project- and programme initiatives, encouraged partnership activity		+				+
		Development of international associations, unions, forums, etc. to coordinate a global agenda		+	+			+

Selected economies perform remarkable progress towards leadership in S&T field. The transition case of China is well known, but even this process took about three decades, requiring deep comprehensive reforms in public administration, as well as economic and social spheres. In other words, the tactics of "quick breakthroughs" do not produce large-scale effects without preliminary long-term preparation and large-scale modernization of the national S&T and innovation systems.

International experience shows that instead of quick breakthroughs in particular directions of leadership-oriented strategies, *a sequential solution of current problems "as they arise" appears a more common practice allowing maintaining steady progress in a predetermined vector of S&T development*. Focusing on current tasks is due to the fact that generalized long-term strategies are not flexible and detailed enough to consider local short- and medium-term problems. But the latter often tend to be gradually accumulated into strong systemic constraints for development. On the other hand, if all the particular factors and decisions are equally integrated into the policy of development and leadership at the highest level, then this will most likely lead to unnecessary complication and inconsistency of strategies and programs

In the context of the observed countries these principles are being regarded within three generalized approaches.

Firstly, despite the correspondence between the levels of strategies, programs, individual major projects and initiatives, the periods of implementation of all these documents can vary greatly. The current High Technology Strategy in Germany, for instance, includes programs that began before its development, and some will continue after its completion. In China, the Five-Year Development Plan coordinates programs lasting for more than one decade. Moreover, the rigid hierarchical configuration of "5-year plans", typical for Japan, China, and Korea, does not contradict this principle. On the contrary, it is being successfully implemented thanks to the continuity of strategies that preserve the development vectors of industries and technological areas. China is somewhat distinguished from the entire group, because, as already noted, it does not implement a unified S&T development strategy (except the respective part of the Five-Year National Development Plan).

Similar trends can be found in other countries, including the United States. And in this respect, the absence of a central (unified) strategy can be considered as an option to maintain flexible strategic S&T policies.

Secondly, a steady rejection of a permanent set of standard macroeconomic indicators as a system of benchmarks and control of their achievement takes place. Obvious problems of integrating such indicators into S&T policy documents are related to their nature: the basic ones (e.g. GDP, inflation

rates, budget deficit) are too general, while specific ones (like scale and dynamics of individual industry markets) do not characterize the system as such.

Focus on development and leadership involves *building up a dynamic image of the "desired future" based on a variety of criteria*. Nowadays almost all countries apply Foresight practices to create a long-term vision as a basis for S&T priority-setting. The criteria and guidelines formed this way are variable, complex, sometimes of qualitative or descriptive nature. A rather striking examples are five-year plan priorities in Korea and Japan, built, in turn, on the basis of officially approved long-term "visions of the future" (foresight studies). In other countries, this approach is used at the programme level, and strategies are guided by the basic (macro-level) S&T indicators. For instance, the German High-Tech Strategy only targets the growth of R&D expenditure, while a more complex system of criteria has been developed for related programmes.

Thirdly, foreign countries demonstrate a marked progress in openness and publicity of S&T development strategies. This allows, among other things, to overcome quite a typical discrepancy between the official vision of potential / priorities and the real situation in sectors and spheres of the economy and society.

Such a gap was especially visible during the recent global economic crises. To overcome it governments had to decentralize the S&T leadership policies at both, decision-making and implementation levels. In the first case, policy instruments are becoming increasingly interdepartmental, which also reflects growing connection between science, industrialization, social policy, etc. (Korea is a good example). Secondly, one could notice an intensification of public interaction tools for all levels and regulatory mechanisms: media resources, communication platforms, demo projects, etc. In addition to the Korean case, public tools are being actively involved in Germany, although it is too early to talk about decentralized decision-making, while the BMBF's role remains fundamental and decisive).

Another important publicity trend in strategic S&T policy is implantation of respective institutional and regulatory reforms into strategies and programmes as a common element among others, with all conventional tools of interdepartmental and public discussion, monitoring and evaluation. For instance, some particular reforms and adjustments appear (along with projects and programmes) in the five-year plans of the Republic of Korea and Japan, and their individual stages are detailed in short-term annual plans.

Participation in formation and implementation of the global agenda is becoming an increasingly significant factor in S&T competitiveness policies (Wagner et al., 2017; OECD, 2018). Emerging big challenges require international efforts to respond quickly and effectively, including, above all, environmental issues, resource availability, security, and so on. As examples of such initiatives

we could mention the Lisbon Strategy (COR, 2020)[4], as well as the EU framework programs, including Horizon 2020 (European Commission, 2020)[5]. Countries pretending for a certain degree of S&T leadership are the most active participants in such initiatives with no exception. Own large international initiative projects and programmes (e.g., LHC (CERN, 2019), a number of current and planned international space exploration missions) based on active partner involvement are quite typical for countries with strong resources and reputation, like Germany, France, the United States, or Japan. In the field of technology and innovation, similar projects are based on creation and development of international associations and forums involving large multinational companies. An example is the international 5G Mobile Communications Promotion Forum (5GMF Committee, 2020), initiated by the efforts of the Japanese government and leading corporations in 2014. Of course, these trends develop in line with national excellence initiatives (Pruvot and Estermann, 2015; OECD, 2014b).

For the leading countries, ability to influence the global S&T processes (transformation or reforms) seems to be the key task within the long-term S&T policy framework (Table 4). *Selection of promising target sectors and markets* for the development of regulatory initiatives in S&T seems to be an important function, since effective proactivity in relation to potential structural changes in the economy plays a decisive role for global competitive positions.

[4] A EU strategic document aimed at achieving global competitiveness of European countries. One of the benchmarks remains the achievement of 3% of the GID level in the GDP of the EU countries (the target level has not been achieved).
[5] EU Framework Program for the Development of Research and Technology (Horizon 2020 - EU Research and Innovation Program).

Table 4 – Solutions addressed to general challenges of S&T leadership policies

General challenges	**Intentions**	**Solutions**		**Germany**	**Sweden**	**China**	**Korea**	**Japan**
Lack of proactivity regarding potential structural changes in the economy	Effective selection of potentially important target sectors for further regulation	Shifting focus from supporting priority technologies towards significant for economy and society technology application areas			+		+	+
		Emphasis on promoting R&D for/by SMEs; strengthening assistance to innovative SMEs		+	+		+	+
		Option	Advancing S&T as a basis of new industrialization		+	+		+
			Balanced distribution of public support between basic research and development	+			+	
Natural limitations of state control and planning tools	Implementation and dissemination of initiative, self-organization and self-regulation mechanisms and practices	Extending S&T policy tools from direct support towards indirect incentives		+				+
		Encouraging entrepreneurial bottom-up initiative		+	+	+	+	+
		Attracting associations and alliances			+		+	+
		Enabling of territorial integration programmes and projects in S&T		+		+		
Setting and implementation of new long-term goals is complicated while maintaining outdated society models	Step-by-step transition to "society 5.0"	S&T development is determined by society's benefit from application of new knowledge, technologies and products by people		+	+		+	+
		The current goal is to achieve a considerable, quick and wide-spread life quality improvement by means of S&T achievements.				+	+	
		The long-term goal is formation of a new society model (in terms of skills, employment, individual development, etc.), based on application and effective use of future technologies					+	+

Foresight becomes an increasingly complex and demanded "future-scanning" inventory. In contrast to forecasts it provides much more comprehensive, flexible and complex vision of challenges as an evidence for emerging strategies. Priority-setting relies less on technology forecasts only. In Sweden, Korea and Japan, the strategic focus is visibly shifting to from priority technologies or technology areas, as such, towards potential areas of application that could be important for economy and society. From this point of view, the sector of innovative SMEs, including service companies, is of particular interest to politicians. In observed countries (to a lesser extent, in China), separate strategic directions are formed to support and stimulate innovation activity of small businesses and R&D outsourcing for this category of companies.

Against the background of this general trend, S&T priorities themselves are formed in different ways. While Germany and Korea emphasize the need to strike a balance between all S&T areas, Sweden, China and, in part, Japan are focusing their support on areas that contribute to new industrialization.

With the further decentralization of S&T development and leadership policies, the desire to *overcome the natural limitations of state control and planning instruments via coordinated and active involvement of economic and social institutions in public policy* is becoming increasingly apparent. The choice between direct and indirect stimulation or their combination provokes wide discussion, although it is mainly determined by the balance of support between S&T and innovation fields. In particular, Japan has been developing tax benefits and preferences for more than a decade, while Germany implements them in a separate policy area only in the current version of the High Technology Strategy (that is, since 2018).

The encouragement of entrepreneurial initiative in the NT sector is a separate policy area implemented in quite different forms and in various ways by most technologically developed countries. Namely we can talk about the support and innovative development of large business (China), or research and experimental projects of small enterprises (Sweden). Specialized civic and educational initiatives (Germany) are also of particular interest. A considerable attention should be paid to the efforts to integrate regional STI systems in countries with obvious regional differentiation / large territory and (or) autonomy (Germany, China).

The agenda for the transformation of economic institutes on the path to further growth and sustainable development is fairly detailed and clear. However, the current shift of priorities from economy towards society requires fundamentally different conceptual solutions. The most general answer in this regard is the structural and qualitative institutional transformation towards "society 5.0", which involves changes not only in the content of socio-economic activity of citizens, their skills and competencies, but also significant shifts in life strategies and values. The new "turn to society" in of S&T development and leadership policy of most countries is expressed mainly in the emphasis on the public benefit from the use of S&T achievements by people.

In case of China, however, this priority is expressed, rather, in a more utilitarian idea to achieve a tangible improvement in the quality of life of most of the population due to new technologies in the shortest possible way. A similar formulation is proposed in the Korean five-year plan, although a deeper long-term goal is also spelled out: formation of a new social model (in terms of education, employment, individual development, etc.), based on implementation and effective use of future technologies. At the moment, Japan has advanced to the greatest extent in shaping the official vision of "society 5.0", having extended this principle to the goal-setting for the whole strategic policy framework.

4. Conclusion

The cross-country study has shown, that breakthrough development and leadership in S&T is reflected not so much in the corresponding declarations (guidelines) at the level of strategic goals and benchmarks, but in actualizing *global challenges and internal constraints, and introducing effective mechanisms to overcome them*. In conclusion, we summarize main features that could be relevant not only for industrially developed economies, but for more or less dynamically developing ones as well.

— S&T-leading countries rarely declare leadership explicitly at the official policy level as policy goals or criteria (such statements were typical for some of them two or three decades ago). An opposite position would make the success of domestic policy dependent on the progress of other economies, and instead of sustainable development would suggest a less rational competition. The intention to use a wide range of quantitative indicators (and target their values) in strategic documents is more likely characteristic of developing economies that are trying to make themselves known in the global space and attract external investors. Leading positions in the world (preservation or promotion), however, may be mentioned in government reports as additional arguments in favor of the effectiveness of existing (completed) policy measures or as indicators reflecting the actual state of national S&T systems.

— The most typical quantitative indicator, still being set as a guideline in the official documents, remains the R&D intensity of GDP. The values of the target indicators are set as evidence of the transition to a new state of the national S&T system. The of publication and patent activity indicators (especially patent) are practically not used as targets, but are actively monitored. Any direct regulation here, as a rule, is ineffective. Patent activity is largely formed according to the market climate and depends on the demand for technology from the real sector of the economy; publication activity is considerably determined by hardly formalizable factors related to motivations and values of researchers, social traditions, culture, etc.

— The most common methods for setting target values are:

- threshold value (or interval) in absolute form;
- increment of a target indicator in comparison with the base time period;
- expert estimation of target criteria achievement based on integral (quantitative and qualitative) evidence.

— Achievement or unachieved targets, in general, are not regarded as clear signs of success or failure of a policy at a strategic level. Such judgments are based on the results of the entire complex of coordinated programs and projects. It allows resources and efforts of performers (at least at the strategic level) to be focused on the planned activities and not distracted by statistics manipulation.

— S&T leadership is being achieved at strategic level, but is actually implemented on the basis of the "small deeds" principle. Programs and projects are mutually agreed within the framework of a single strategy, but are focused, first of all, on timely and effective solution of local, sector-specific, and other current problems, avoiding their accumulation.

— Strategies, priorities, programs and targets are not adopted simultaneously and unilaterally, e.g., by a single decree of the government, subordinating the rest of the regulation and containing a lot of details in all directions. On the contrary, as all the components of the framework and planning documents are being developed and adopted, there is a lengthy public discussion involving expert analysis of an extensive information base, the results of previous steps, and foresight procedures. When revising strategies, as a rule, programs and projects retain their previous plan.

— Strategic documents that establish, inter alia, principles and guidelines for S&T leadership, also determine and explain the structure of coordinated programs, projects and other activities, and establish timelines for their implementation. However, they do not define hard targets and do not regulate directly the actual or planned distribution of public funds for coordinated programs and projects, thereby ensuring their flexibility, autonomy and stability.

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