BUSINESS AT OECD CONTRIBUTIONS TO THE CSTP HIGH-LEVEL ROUNDTABLE

Introduction

Business at OECD welcomes the timeliness and forward-looking focus of the High-Level Roundtable of the OECD Committee for Scientific and Technological Policy (CSTP), and the opportunity for the business community to contribute to this session.

The time has come to transform traditional STI policies, priorities, and organizational structures to reflect multiple, massive STI disruptions, paradigm shifts, and transitions now underway in the STI environment. This paper, therefore, summarizes key topics and actions for each of the Roundtable's four discussion topics.[1]

Session 1 – Are mission-oriented programs an efficient way for government to influence research and innovation?

The private sector is capable of producing increased public benefits and achieving mission-oriented goals, globally and domestically. Realizing those benefits, however, will require new policy thinking and measures. To develop those measures, it is necessary to analyze and understand what now drives the STI enterprise in business, government, and other key stakeholders.

First and foremost, STI should be understood as a systems-level ecosystem. Without this system-level understanding, we currently see numerous research and innovation policies that are focused solely on relatively narrow policy objectives or ministerial priorities that often have unintended and undesired consequences.

Second, CSTP and governments should focus STI policies not only on specific programs, such as a particular type of research program or R&D tax credits, but more on "thematic priorities" that cut across research, innovation, disciplines, and business sectors.

Third, many of the most important advances in research and innovation increasingly occur at "intersections and interfaces" or through innovative new types of collaborations, such as collaboratories or mission-oriented public-private partnerships. They occur both at the intersections and interfaces of government, business, universities, and non-governmental organizations and between previously discrete business sectors, disciplines, and government ministries. CSTP and governments should focus more work on understanding the changing nature of these "intersections and interfaces" and on developing STI policies that promote them.

We recommend that societal benefits from STI and mission-oriented goals can be enhanced by focusing more attention on five crucial pillars of the STI ecosystem:

[1] This paper draws on the practical experience of a wide and regionally diverse business constituency and provides a considered assessment of priority issues that affect its members' ability to fully embrace the benefits of science, technology and innovation policies. The topics mentioned in the following should be considered in addition to and complement those listed in other *Business at OECD* publications, including the paper *Business at OECD* Science, Technology and Innovation Policies For Society - Priorities for Future OECD Work.

- **Invest in the Foundations of Research and Innovation**

  The building blocks of the emerging 21st Century STI ecosystem are those areas where government policies, investments, and organizational structures can provide the greatest value. We encourage governments to undertake additional efforts to understand and embrace how key drivers such as AI and data, convergence, and exponentials are transforming the structure, conduct and sharing of research – including the changing role of universities, innovative business models, entrepreneurship, open and inclusive innovation, collaborative platforms, and "de-risking toolkits."

- **Create Next-Generation Infrastructure, "Infratechnologies", and Foundational Tools – Especially Next-Generation Digital Infrastructure**

  Government investments and other support for "Tools" and "Infratechnologies" provide high returns in driving scientific progress, economic value creation, and the ability to solve societal grand challenges and constitute new types of public goods. In this context, we emphasize that STI government-led infrastructure that supports knowledge creation, technology development, and economic value is critical, but eroding or out-of-date.

  Infrastructure no longer is about just bricks and mortar or equipment – it requires government policies and funding to support new types of infrastructure such as infratechnologies, prototyping and scaling, metrology, and access to pre-competitive commons.

  Governments should support the development, adoption, and diffusion of next-generation digital infrastructure, including broadband availability, access to cloud resources, and data exchange platforms and repositories.

- **Focus on Human Capital and Workforce Readiness – Especially High-Quality STEM Education for All, Data Literacy, Statistical Reasoning Skills, and Lifelong Learning Opportunities**

  STI workforce and human capital needs for business are changing fast – but government policies, educational programs, and labor policies have not kept pace to build a talented, diverse, lifelong learning workforce aligned with 21st Century STI needs.

  STI also is changing the nature of work, the value of skills, and workflows. Much greater attention needs to be given to understanding these transitions and the changes in policies and programs required to adjust to them. This means encouraging a different set of workforce characteristics than were emphasized in the past – an ability to engage in rapid iteration and learning processes, take prudent risks, invest in their own skills, and value soft skills and team orientations.

  Particular human capital and workforce needs are arising with the rapid growth of AI, Machine Learning, and Data – ranging from addressing dislocations and smoothing transitions or access to a limited talent pool to new curricular approaches to talent development, new curricula and teaching agendas from data literacy to machine learning engineering, and supplementing traditional degrees with new types of skills certifications and transferable credentials.

  And finally and, perhaps foremost, STI human capital and workforce readiness must deal with a future of research, innovation, and work that involves human-machine collaboration at ever more complex levels.

- **Fuel the Engine of Private-Sector Innovation**

  Governments should address new barriers to research and innovation, and ensure that the framework conditions essential for enabling STI in this new era are in place, including supporting innovative entrepreneurs, ensuring the right framework conditions for research and innovation, promoting data access and diffusion to the fullest extent possible, accelerating lab-to-market commercialization, and fostering innovation ecosystems. At the same time, government oversight and regulations should adapt to the changing landscape of STI to ensure these policies do not unnecessarily impede the quick uptake of new tools which

could benefit society at large.

- **Catalyze Breakthroughs for Global and National Priorities**

  Maximizing the impact of research and innovation increasingly means identifying those areas where focused investment and policies can achieve transformative results to meet multiple, interlinked challenges – delivering societal solutions, providing new sources of sustainable economic growth, advancing the frontiers of knowledge, and enhancing human well-being.

Session 2 – How to foster international co-operation in research and innovation?

International co-operation in research and innovation is critically important to business and provides a number of benefits, including access to valuable additional and distributed expertise, de-risking and sharing costs, pursuing complementary research and innovation approaches, and avoiding the over-duplication of efforts. This is particularly important for global public goods and for achieving faster progress on common goals at lower cost, especially difficult societal grand challenges.

Business at OECD recommends more OECD work related to three important questions that have been under-appreciated or absent in previous or current work related to STI international co-operation. They all involve challenges that are becoming strong headwinds for business and threaten the numerous benefits that accrue from international cooperation in STI and from transnational co-creation.

Who Benefits?

Prudent and realistic STI policies for international activities must adjust to the reality that the political and social context in which global research and innovation now take place is changing rapidly, and global competition and capabilities are broadening and deepening at a rapid rate.

Who wins and loses from international co-operation – and how – dominates much of political discourse but often not that of STI policymakers. Better understanding about who captures the economic value and other benefits of STI funding and investments in international research and innovation – and how - is a compelling issue for future work.

In today's highly connected world, a research discovery made in one country or a business innovation introduced in another one is soon widely known in others. As a result, the competitive advantages may not go to the nation and taxpayers that primarily funded the research but to the nation(s) that can use it most effectively to develop new technologies or introduce new business innovations based on the research.

This is fuelling domestic political debates in many OECD nations that create considerable uncertainty and barriers for business operating on a global or regional scale. An increasing number of voices argue that international co-operation in STI either is a unidirectional effort that disadvantages broader national interests and security, or represents the unwise expenditure of scarce domestic taxpayer funds for benefits and jobs that are not captured by the funding country.

Understanding the Role of Competition and Integrating National Competitiveness

The new STI global multipolarity creates new government and business challenges, as well as many opportunities. Much of the OECD work programs on international co-operation tend to focus on the benefits, which is desirable.

But business also could benefit from more balanced assessments that include a greater focus more on the other forces at work, such as intensifying competition and the realpolitik of STI in the broader geo-economic and geo-political context. For example, this would include an understanding that governments have mixed motives for supporting international cooperation. A primary goal for many countries is to enhance their own global competitiveness and to differentiate their STI enterprise for national advantage.

Responding to the Emerging Challenge of a New Era of Innovation Mercantilism, Knowledge Protectionism, and Trade and Investment Barriers

Growing STI storm clouds are building that risk a perfect storm of innovation mercantilism, knowledge protectionism, and technology-oriented trade and investment barriers. For example, technology-directed trade policies and conflicting regulatory regimes are becoming major new obstacles to transnational collaboration and co-operation in research and innovation. The risks to business are significant, including those related to uncertainty and regulatory conflicts.

The growing list of topics now includes:

- forced technology transfers;
- trade distorting R&D subsidies;
- the role of state-owned enterprises in STI; and
- mandatory investment requirements.

Changing conceptions of national security and security rules are also having an increasing impact on business research, innovation, and international co-operation. This is especially true for business and research universities that operate on a global or regional basis. CSTP could provide valuable work in promoting dialogue and developing recommendations or best practices for addressing legitimate security concerns while maintaining an open international research and innovation environment.

Session 3 – Realizing the Promise of AI and Data Science

The Mega-Trend of AI and Data Science

To be sure, AI, Data Science and digital technologies are an overarching 21st Century mega-trend, and we are entering the Era of Data Disruption. It remains true that each 10-year cycle in computing has brought a 10-fold increase in access to compute. What is different now is that this is the first computing cycle in which multiple core technologies are emerging and converging at once.

Digitization now is the new infrastructure for innovation in the 21st Century. Data-driven business models are fundamentally changing the way business is performed – including from hardware to software, from product to service and solution, and from product to platform – and are embedding AI and data into a broad range of business processes.

This new data-driven era combines AI, ML, Data Science, blockchain, augmented/virtual reality, cybersecurity, and new computing tools to reinvent many business models, markets, and methods. Together, these new digital technologies are driving business in all fields to rethink how they collect, analyze, use and act on data across their entire value chains. It promises to spur a new era of productivity growth and economic value creation. These tools also significantly expand the ways in which business can collaborate with government for achieving numerous shared goals, including innovating government itself.

AI and Data Science underpin and drive STI

CSTP (in concert with CDEP and others) should build on the OECD's Going Digital project across the full spectrum of STI. In particular, it should focus on creating the necessary foundational building blocks for Digitization and Data 2.0 in STI and business innovation – human capital, shared infrastructure and infratechnologies, innovative collaborative mechanisms, cutting-edge data-driven research, and entrepreneurial ecosystems – for a forward-looking research enterprise and innovation hub. In short, we need to better foster our collective readiness for the challenges and opportunities of Digitization as a defining trend of the 21st Century.

AI and Data Science, of course, should be considered essential building blocks and interfaces for the next-generation STI ecosystem. In particular, AI and Data Science underpin and drive STI by:

- Accelerating the rate and diversity of scientific discovery, innovation, and value creation;
- Opening up new fields of inquiry and enabling research trajectories that would not be possible without it;
- Encouraging a broad range of new enabling tools, data analytic techniques, and sophisticated algorithms that can serve as core foundations or platforms not only for scientific and technological research but also for next-generation economic growth and business competitiveness;
- Creating and facilitating a broad range of new shared research and innovation infrastructures that can be shared broadly, easily accessed, and linked to new types of knowledge networks and markets;
- Increasing greater understanding of human and social processes and interactions, including human-machine and machine-to-machine (M2M) interfaces;
- Embedding AI and data technologies into existing business processes; and
- Promoting and developing new types of 21st Century skills and jobs – including through new approaches to education and lifelong learning.

Leveraging Big Data

In this context, a major focus should be on ways to safely and smartly leverage big data. STI, clearly, has entered the age of big data, whereby the volume, variety, velocity and complexity of data are exploding at record rates. It represents not only a quantitative change for applications but also a paradigm shift in approaches.

To leverage big data for STI, we need the ability to support different types of information, the infrastructure to store and access massive data sets, and the flexibility to take advantage of it. But most of all, these data sets first must be sustained, shared and used broadly where possible.

When considering ways to leverage big data, policymakers should take a holistic approach to enhancing access to data, as set forth in the OECD's Integrated Policy Framework. Rather than regulating access to privately-held data, contractual autonomy should prevail unless in case of market failure, and industry initiatives like data market places should be promoted to incentivize B2B sharing. Concerns over data protection, privacy, and security, which are sometimes at odds with increased access, should be duly considered when data may be shared or used broadly.

In this context, we emphasize the need to facilitate the free flow of data across borders, and to refrain from imposing localization measures requiring the local storage or processing of data or the use of local computer facilities. Additionally, policy objectives to enhance access to data or leverage big data should not harm the economic incentives to collecting, curating, and analyzing data in the first place.

The challenge of big data goes beyond the sheer volume of information. There is the diversity and

complexity of data, which comes in various formats and from disparate sources. There are thousands of "islands" of data that must be constantly aggregated, stored and analyzed.

As a result, we also need new data analytics — algorithms, models, simulations, software platforms and other prediction tools to extract and use timely data from massive and often widely distributed data sets. By aggregating data from large cohorts and disparate data sources we increasingly find unexpected connections and new insights. But this requires solving often difficult policy challenges related to making the best use of the massive new data, data analytics and software systems.

The real test is how to turn this massive data into actionable information — for researchers, business, government, and many others. We need to be able to identify trends and new patterns, as well as create predictive analysis that can support better-informed decisions. All the while, these analyses must be cognizant of the larger policy framework of data use, especially privacy and data protection (e.g., when personal information can be identified through data analytics of disparate).

Business at OECD, therefore, recommends that the OECD and governments work collaboratively with business and other key stakeholders to address a number of key policy challenges.

- Compatible Big Data Governance Frameworks
- Trustworthy Environments for Data
- Use-case-oriented and Technology-neutral Regulations for the Protection of Personal Data
- Sustainable Research Data and Innovative Finance and Funding Mechanisms
- Intellectual Property, Access and Diffusion
- Creating Precompetitive Data-Sharing Infrastructures and "Information Commons"
- Competitive Cloud Storage and Computing Infrastructures, Platforms and Software
- Policy Frameworks for Data Technical Challenges That Threaten to Become Critical Bottlenecks to Research and Innovation

Public policies to assist researchers and innovators

To seize the opportunities raised by AI and data science public policy needs to take a holistic approach, and in this context the OECD may address further questions including:

- How can public policy, new incentives and funding policies assist researchers and innovators with the broad range of technical challenges they currently confront?
- What new policies, funding and incentives should be developed together with the private sector (i.e., co-regulation) to promote education and training not only for data analysts and AI experts but also for researchers, regulators, business, and government officials who increasingly require "data fluency"?
- Who will support and pay for the training and capacity-building that is needed? What new types of investments are needed to provide core competencies in data analytics, data management and storage, and systems management?
- How can these educational and training programs be designed, funded and implemented so that they are broadly diffused and not limited to only a small set at the leading edge?
- How can we best address cultural attitudes, career rewards and human behaviors impeding broader data sharing and collaboration?
- How can policies protect the economic incentives of collecting, cleaning, and analyzing data, as well as uphold data protection and privacy of personal information, while also leveraging the insights that big data may provide?

Session 4 – Future Challenges and Opportunities for STI

Integrating and Advancing New Thematic Priorities

Key thematic priorities have emerged in recent years that should be seen as organizing principles and key drivers for current and next-generation STI policies and programs. These new trends affect much of STI and include

1) ***convergence;***
2) ***complexity;***
3) ***capital markets;***
4) ***connectivity;***
5) ***collaborative Mechanisms;***
6) ***interfaces and intersections;***
7) ***knowledge networks and markets;***
8) ***scalability; and***
9) ***the increasing role of engineering methods and mindsets in research, innovation, and business models.***

Among a number of emerging thematic priorities, we highlight three in order to provide examples:

- ***Convergence***

  Convergence represents the integration of knowledge, tools, infrastructure, and modes of thinking from multiple fields to form a comprehensive framework both for addressing scientific and societal grand challenges that exist at interfaces and for creating new market opportunities and value creation for business.

  This requires STI policy that recognizes that solutions to complex and multi-faceted societal and scientific challenges increasingly depend on research and innovation at the intersection of multiple disciplines that go beyond interdisciplinary approaches to create new, integrated modes of thought. In many cases, it changes fundamentally the questions we now can ask and the answers to them. But it also requires "re-thinking" the structures, funding models, and collaborative partnerships.

- ***Capital Markets and STI***

  In an era of government fiscal restraint and stable or decreasing government investments in STI, it is important to find new ways to support the research enterprise, as well as leveraging current funding, both public and private.

  Until now, the CSTP and STI policymakers have paid limited attention to the opportunities presented in tapping the large financial flows available in capital markets, spurring new impact investments in STI (especially for societal grand challenges), and better integrating social entrepreneurship, venture philanthropy, and innovative public-private financing mechanisms into mainstream STI policymaking.

- ***Exponentials***

  Professor Freeman Dyson famously argued that scientific revolutions and major STI and societal paradigm shifts are propelled largely by the creation of new tools. Rapid, disruptive advances we see today, and can expect in the decades ahead, come from the confluence of multiple new tools – most notably in the digital world but also in the biological world and new

cyber-physical interfaces – and, increasingly, the intersection of all three domains.

This particularly is true for so-called "exponentials" because they are accelerating faster than the pace of Moore's Law and are providing ever-greater functionality at ever reduced costs. And the real power and transformational impact on STI comes from the synergies achieved by combining these "exponentials" in new ways or in "mixing and matching" them for complex challenges.

Innovating STI in an Era of Multiple Transformational and Exponential Technologies

A new era of multiple transformational and exponential technologies requires rethinking STI conceptual models and innovating new policies. Many of them increasingly intersect and these new interfaces become "game changers" for STI.

Numerous technological revolutions are unfolding and accelerating – and many of them are linked. To be sure, Artificial Intelligence (AI), Machine Learning (ML), and Big Data are transformational and require extensive attention. But they are not alone. Exponential progress in other foundational technologies or "portfolios" not only intersects with AI and Data in many ways but also create massive opportunities and challenges for STI policy. They include:

- Quantum computing and next-generation information science
- Synthetic biology/engineering biology and the emerging bioeconomy
- Novel Materials
- Energy
- Human-machine interfaces, including brain science, neural networks, and human cognition
- Robotics, augmented and virtual reality, and enhanced performance
- Internet of Things/"Internet of Everything"

Addressing the Policy Implications of Changing Innovation –e.g., Alternative Innovation Models and the STI Policy and Funding/Investment Gaps in the Manufacturing Innovation Process

Business at OECD recommends to CSTP and government the need to prioritize work related to new innovation models. Three examples include:

- ***Address the "Second Valley of Death"***

  STI policies and programs have devoted significant attention to bridging the "Valley of Death" between basic research and "proofs of concept" and commercializing the results of that fundamental research. Less attention has been given to the critical importance of the "Second Valley of Death" about how to scale early stage commercialization or prototypes so that they can operate and compete at commercially viable levels.

  For example, when questions and challenges emerge in the commercialization or innovation process, innovators often need to shift back to basic research or early-stage R&D to identify solutions, or better understand the emerging barriers. In this way, the development of knowledge involves feedback and iteration at different stages of the research and innovation process than is the focus of most current STI policies and programs. But public funding is ill-equipped to deal with the basic research or early stage R&D that comes from business as part of these feedback and iteration loops.

- ***Understand the STI Implications of Alternative Innovation Models***

Business could benefit from the CSTP and governments prioritizing more work around new models of innovation (beyond digital innovation only) to better understand the changing nature of STI policies, and what is needed to support and enable private sector led growth. Examples:

- **Extended pipeline model.** Under this model certain R&D organizations support the entire technology development process, from basic research to initial commercialization. Unlike the pipeline model, in which the government's support is disconnected from the rest of the innovation ecosystem, under the extended pipeline model the government's role is deeply connected to the rest of the system. Under this model, government helps to support the evolution of technologies across all stages of innovation.

- **Induced innovation model.** Innovation that follows this model is more business-led because the parties involved have a market niche that the research needs to meet. Research under this model is more likely to lead to incremental advances because it is conducted in response to market demand.

- **Manufacturing-led model.** Under this model, innovation is pursued with the main objective of next-generation manufacturing. This model describes innovations in production technologies, processes, and products that emerge from the manufacturing process. The production process is supplemented by applied research and development. It is typically industry-led but may have strong government support.