Winning back the future:

National Research & Innovation Centers to Foster Emerging Technologies

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Winning Back The Future:

National Research & Innovation Centers to Foster Emerging Technologies

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AT A GLANCE

COVID-19 and the new reality created by it has demonstrated, like never before, that "Disrupt or Be Disrupted" applies to nations and governments as much as it applies to enterprises. Driving innovation, focusing particularly on emerging technologies, should be an essential priority for governments to be in the driving seat of shaping their nations' future. This is imperative to stay relevant at a time when the major tech corporates continue to show the way to win and set the expectations of the citizens.

Government-sponsored National Research and Innovation Centers (NRICs) can play a central role in championing national agendas to foster emerging technologies and gradually evolve into R&D practitioner and orchestrator roles to address scale, focus or coordination gaps that characterize most countries' approach to these technologies.

To fulfil their mandate as innovation catalysts, NRICs must earn their position at the center of a broad community encompassing public sector, private sector and academic bodies, through mutually-beneficial strategic alliances and focused collaboration partnerships.

As innovation leaders with outputs that can be relevant to a wide range of beneficiaries, domestically and internationally, NRICs are best positioned to set the example for a new breed of public entities which can serve the greater good while being financially sustainable, through various funding mechanisms.

Establishing an NRIC might seem deceptively simple but, in reality, there are several major hurdles to overcome to get it right, including those around sponsorship, empowerment and access to talents. NRICs will need to compete for top talents from, limited talent pools. Securing internationally recognized R&D superstars as magnets to attract top talents and applying field-proven practices to develop and retain these talents can position NRICs competitively as best places to work for – an elite title typically reserved to the Googles, Facebooks and Amazons of the world.

Artificial intelligence (AI), the internet of things (IoT), Blockchain, 5G, Robotics, Biometrics, 3D printing, Virtual and augmented reality - Emerging technologies are changing every aspect of our lives, and the impact is just beginning to show. With profound implications for national security, education, healthcare, mobility and economic competitiveness, they command government attention as never before. A growing number of countries have established strategies focused on one or more emerging technologies. More than twenty countries have announced national AI strategies since 2017. And many, like the United Kingdom, China and Kingdom of Saudi Arabia, are also sponsoring centers of excellence to serve government priorities and drive research and innovation in emerging technologies.

"With their profound socioeconomic implications, emerging technologies command government attention as never before"

Government objectives vary. Continuing with the AI example, we see three broad approaches. Sweden and Denmark are both using AI adoption to bring socioeconomic benefits to their citizens. They emphasize local technology growth to enable government-related sectors and people's well-being. The UAE, France, Canada and India are aiming to leverage their existing competitive advantage on AI to play an international role. Meanwhile China, USA, UK and South Korea – already global leaders in AI – are developing it as a separate growth sector.

This paper examines the role that National Research and Innovation Centers (NRICs) can play in fostering the development, understanding and application of emerging technologies. NRICs can be an important pillar of national technology strategies when a country's current efforts lack:

- Scale - each private and public sector entity works on a small scale on specific technologies or problems
- Focus - no participant is 100% focused on the most strategically important technologies
- Coordination and cohesion – work is fragmented, and scattered across many companies, universities and research labs.

"NRICs can be an important pillar of national technology strategies when a country's current efforts lack scale, focus, coordination or cohesion"

An NRIC at the center of national emerging technology efforts, coordinating across sectors, can address deficiencies and supercharge investments, R&D, and solutions development.

National Research and Innovation Center (NRIC) Scope

An NRIC may span multiple emerging technologies. Dubai Future Labs encompasses robotics, automation and AI. More commonly, like Norway's GENOEK Center for Biosafety or Singapore's Centre for Quantum Technologies it can focus on a specific tech grouping. And while many NRICs are primarily sponsored by national governments, which is the focus of this perspective, others like Canada's Blockchain Research Institute and the UAE's Center of Research on FinTech, Blockchain and Smarter Logistics originate in the private sector.

"Four key roles that NRICs can play in advancing a country's emerging technology capabilities, translated to nine core activities"

There are four key roles that NRICs can play in advancing a country's emerging technology capabilities.

- Defining and driving strategy
- Orchestrating research
- Developing solutions
- Building expertise

Some, like the UK's Alan Turing Institute are active across multiple roles. Others concentrate on a few key areas to fill gaps in their country's existing infrastructure. Inside each role, or area of scope, are core activities commonly seen across NRICs (Exhibit 1).

Defining and Driving Emerging Technology Strategy

In this capacity, the NRIC works with key stakeholders to develop the national

EXHIBIT 1 | NRICs Can Play Four Key Roles in Advancing a Country's Emerging Technology Capabilities

emerging technology strategy. It translates direction from the government into a detailed strategic plan. It develops key strategic initiatives, organizing them into an evolving roadmap to guide decision-making, investment and action. Furthermore, NRICs often advise government entities on emerging technology priorities, risks and adoption.

Complementing its strategy mandate, the NRIC helps advance emerging technology policies, and advises government entities on related policy decisions. The NRIC may research and publish papers on technology policy, and advocate with the government for the adoption of specific policies.

Central to this role is bringing the right stakeholders and perspectives to the table. The UK's Alan Turing Institute works with multiple levels of government to identify priorities related to data science and AI, inform policies, and evaluate their outcomes, as well as provide public services using these tools. The UAE federal government's RegLab collaborates with the Dubai Future Foundation and emerging technology innovators to craft legislation based on "experimentation corridors" – physical platforms for testing future focused technologies and business models in addition to limited time experimental licenses.

Orchestrating Emerging Technology Research

Most NRICs advance basic and applied emerging technology research. They may provide incentives to external researchers or participate directly in internal or joint projects. Internal studies are conducted by either full-time employees or students and researchers seconded to the NRIC for a specific project. Joint research may include scholarships granted to academic or research institutions, or joint supervision of PhD students.

UK's Alan Turing Institute for data science excels at leveraging seconded talent to pursue internal research. It employs a 'fellowship' model, engaging researchers and students from leading UK universities to work on its programs while gaining access to unique assets, including government datasets. KSA's recently established National Center for AI follows a similar model, partnering with researchers from top local universities on internal projects.

Another example is the Centre for Quantum Technologies (CQT), designated as a Research Centre of Excellence in Singapore. It brings together physicists, computer scientists and engineers to do basic research on quantum physics and to build devices based on quantum phenomena. CQT is hosted by the National University of Singapore, but also includes staff from Nanyang Technological University and collaborates with private sector players on use case development. Its published papers include individual and institutional collaborators from 50 countries worldwide.

Developing Emerging Technology Solutions

NRICs can validate and accelerate technology adoption by directly developing or indirectly incentivizing solutions to real-world challenges. They may build these applications in-house for use by government or other stakeholders. Or they can invest in solutions development through partnerships, incubators, and startup accelerators.

NRICs:
The evolving role

Singapore's Centre for Quantum Technologies (CQT) demonstrates how an NRIC's research mandate can evolve to keep pace with technology and national priorities. Its 2018 annual report included the following comment from the Center's Director: "CQT was established with a mission to do basic research – and this goes on as usual...

We cannot, however, just wait for commercial things to happen. The time has come for a fruitful discussion among researchers, entrepreneurs, managers, and investors who share an interest in quantum technology, and CQT must play a leading role in such discussions."

One NRIC that consistently translates research efforts into marketable solutions is Australia's Data61, specializing in data sciences, digital, engineering and design. In addition to productizing its research, Data61 has spun out multiple companies including Emesent (drone autonomy and data analytics, automating data collection and analysis in GPS-denied environments) and Ambiata (applying machine learning research to enterprise data assets for real-time automated decision-making).

Building Emerging Technology Expertise

Finally, NRICs can build understanding, skills and expertise through awareness, training and certification programs. Using conferences, networking, hackathons and more, they assess needs and bring emerging technologies into the mainstream.

NRICs often take an active role in training both students and industry professionals. They identify methods and tools, oversee the development of curricula and content, and coordinate program delivery to different stakeholder segments.

In 2017, Finland was the first EU country to publish its national AI strategy, aiming to become a major player in the field. Economy Minister Mika Lintilä, said, "we'll never have so much money that we will be the leader of artificial intelligence. But how we use it — that's something different." An early initiative to raise awareness was training 1 percent of the country's population, approximately 55,000 people, in the basics of artificial intelligence. The University of Helsinki, industry partners, and the Finnish government collaborated to design and roll out Elements of AI, a free online course with up to 60 hours of content.

Interestingly, after reaching their goal in just four months, Finland expanded its ambition and now hopes to train 1 percent of the world's population. So far, more than 400,000 students from 170 different countries have enrolled. At least 15 other countries have reported plans to create and launch similar courses for their own citizens. And today, more advanced courses are being developed. In the same vein, Dubai Blockchain Center organizes free Blockchain 101 awareness sessions in Arabic and English to raise awareness on the topic.

NRICs are also well placed to sponsor apprenticeship programs, combining coursework with on-the-job training in government or industry. AI Singapore's Apprenticeship Programme grooms local professionals and enhances their career opportunities by offering a 2-month course covering areas like Deep Learning and Machine Learning applications, coupled with 7 months working on a real-world AI problem with government and private sector partners.

Collaborations

Collaboration with government, academic and private sector stakeholders is essential to NRIC relevance and success (Exhibit 2). To fulfil their mandate, NRICs must earn their position at the center of this broad community.

The Alan Turing Institute exemplifies commitment to rich, varied collaboration:

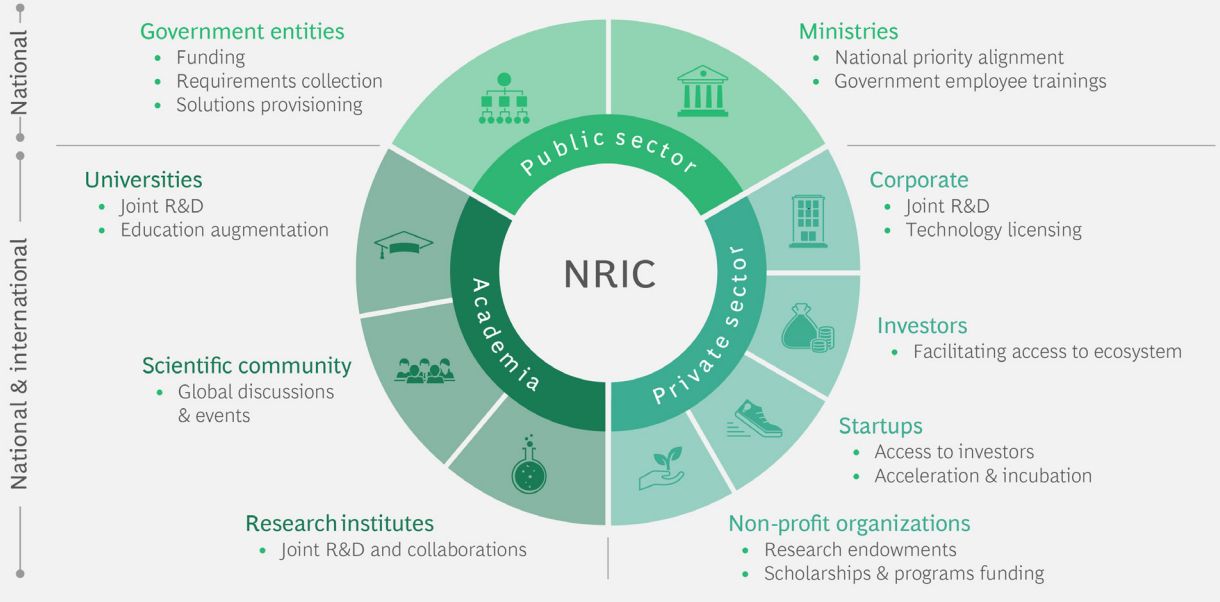
"Being a national institute enables us to deliver benefits that a single university could not deliver alone. We break down disciplinary boundaries; at the Turing, computer scientists, engineers, statisticians, mathematicians, and scientists work together under one shared goal, with no departmental boundaries. We are a collaborative hub, with roots in universities and centres of research excellence across the UK, and strong links to a growing network of industry, public sector, and third sector partners. Crucially, we are a convening power, bringing together the best talent in the data science and AI community to speak to industry, policy-makers, and the public."

"To fulfil their mandate, NRICs must earn their position at the center of a broad community."

Public Sector

The public sector, including government ministries and other entities, plays a critical role in kick-starting NRIC operations and sustaining its activities.

EXHIBIT 2 | To Fill Their Mandate, NRICs Must Earn Their Position at the Center of a Broad Community



Government priorities, strategy, decisions and requirements provide the NRIC's foundational mandate. This sector is also a key provider of funding, especially for startup and core activities. The NRIC will typically collaborate with multiple government actors to develop, detail and/or implement national strategy for its targeted technologies.

The public sector is also a consumer of NRIC-generated research, training and solutions. NRICs can play an important role in building public sector workers' emerging technology capabilities.

Academia

Encompassing universities, the scientific community, and research institutes, academic collaborations supercharge NRIC R&D capabilities. They provide research talent, technology expertise, and resources including funding, access to global networks, and the use of specialized labs, tools and physical properties. While an NRIC may be national in scope, academic collaborations are often international. A strong network of universities, scientific groups, and research centers keeps the NRIC on top of new developments worldwide. The Alan Turing Institute strongly leverages its academic collaborations with 5 founding and 8 additional universities.

As well as amplifying its research capabilities, academic collaborations can also help an NRIC develop and offer training. Australia's Data 61, for example, created undergraduate and post-graduate courses in collaboration with the University of New South Wales (UNSW Sydney) and the Australia National University on topics ranging from theory of computation to algorithm verification.

Private Sector

Private sector collaborations, with established corporations, investors, startups, and philanthropic / not for profit organizations, are essential to NRICs' success. These partners provide funding through donations, underwriting research and investing in startups. They act as a bridge between research and market by licensing solutions and other types of technology transfer. Private actors can also leverage NRIC services (e.g., training, consulting) according to their agenda and priorities.

In general, private sector partners provide a corporate perspective and ensure that the NRIC stays application and market-focused. Singapore's Centre for Quantum Technologies collaborates with private sector corporations to advance the commercialization of technology innovation; e.g., its commercial partnership with Singtel to drive quantum key distribution.

Some partnerships cut across all three sectors, like these Australian examples. Innovation Central Sydney brings Data61 together with CISCO, NSW Department of Primary Industries, University of NSW, and NSW Farmers to develop innovative solutions around the Internet of Things. The Sixth Wave Alliance is a collaboration among industry, research and government players to establish a country-wide robotics strategy and accelerate creation and adoption of robotics and automation technology. Both initiatives illustrate the power of a national mandate, prioritizing technology to address key Australian challenges; e.g., large landmass but low popu-

lation density, agriculture in a dry climate, with the expectation that solutions will have broader global applications.

Types of Collaboration

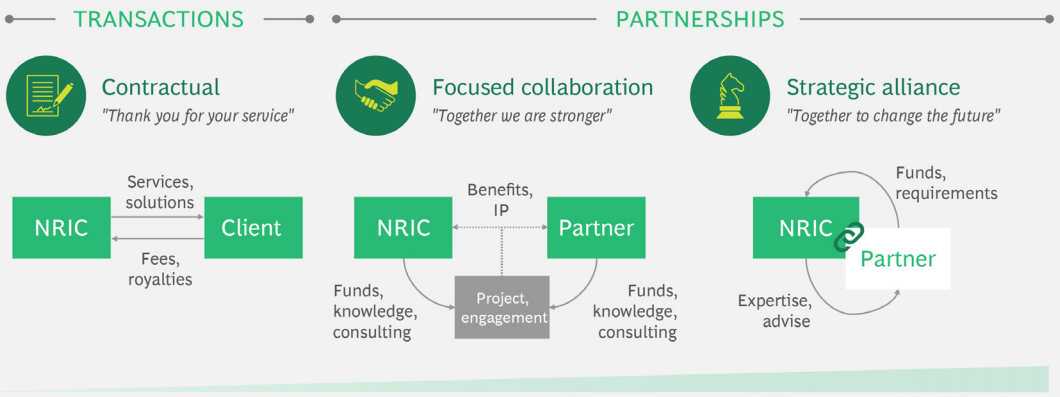
Collaboration can take many forms (Exhibit 3). On the transactional end of the spectrum, contractual relationships spell out time-bound rights and obligations of each party, without expectation of permanent cooperation. These include fee for service arrangements like training, consulting, and technology transfer.

Focused collaborations involve deeper, more multifaceted connection. These short and medium-term arrangements to including collaborative research and business accelerator / incubator programs to share resources for a specific activity and time. A great example of focused collaboration is AI Singapore's program to solve companies' AI challenges. The NRIC helps companies to define the problem statement and find and deploy the necessary talent. It also matches 1:1 the funding required to solve the issue.

Strategic alliances are long-term commitments in which the partners contribute capital, assets and intellectual property towards a common goal. Flagship strategic alliances provide funding and help bolster the NRIC brand. Execution-focused alliances with established partners can also jump-start an NRIC's solution development and commercialization efforts. The Alan Turing Institute, for example, partners with HSBC on a long-term research program in finance and economics. Its goal is to help economists, researchers, policymakers and businesses to better understand economic trends.

"Three collaboration architypes NRICs can pursue: "thank you for your service", "together we are stronger", and "together to change the future"

EXHIBIT 3 | NRICs Can Pursue Three Collaboration Architypes — Strategic Alliances Are the Strongest



Value	Service for revenues	Joint funding / shared profits	Full value from alliance
Risk sharing	Business as usual	Shared	Permanent
Investment needed	Low	Medium to high	High
Strategic horizon	Short-term	Medium-term	Long-term

Funding

NRICs typically rely on public funding, as governments invest in activities generating a strategic or public benefit. However, by diversifying funding sources, they can become more financially sustainable, expanding capacity and proving their value while reducing risk. There are at least five different mechanisms or sources NRICs might consider to find their activities (Exhibit 4).

"Five funding sources NRICs can consider to become more financially sustainable, expanding capacity, proving their value and reducing risk"

Public Funding

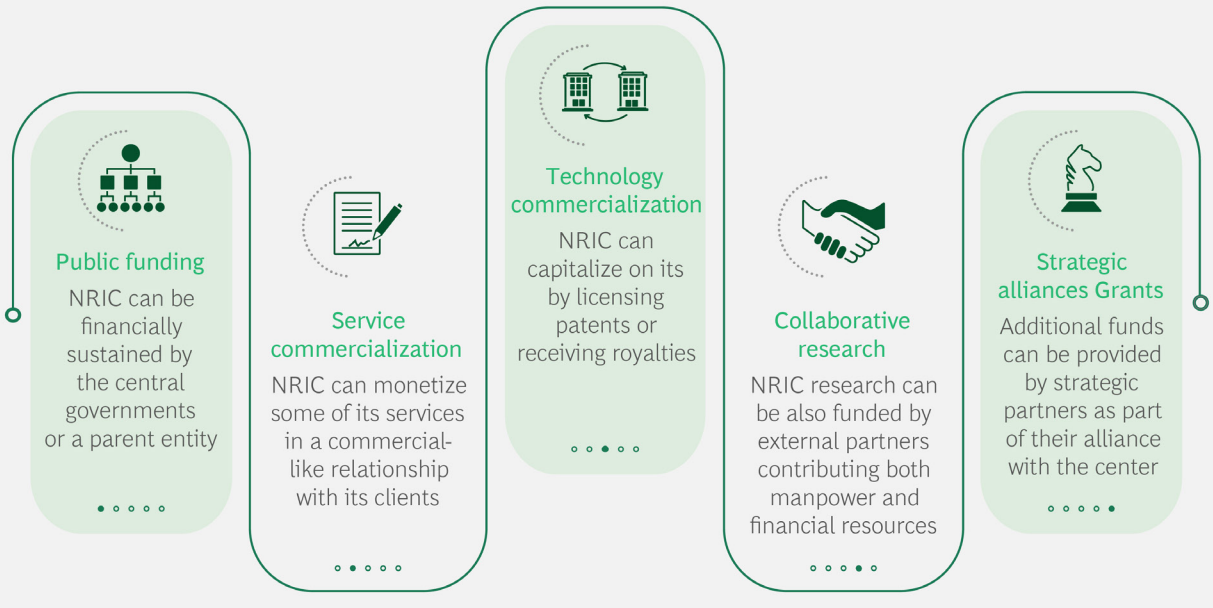
NRIC government funding typically includes initial investments, annual contributions, and periodic grants to pursue specific initiatives. This money supports core operations.

For example, Data61 is funded directly by Australia's national science agency, Commonwealth Scientific and Industrial Research Organization (CSIRO). CSIRO grants budget to Data 61 and other business units as part of the country's "general research" funds to Data61 and other business units. Singapore's Centre of Quantum Technologies was established with core funding from the National Research Foundation, Prime Minister's Office, and the Singapore Ministry of Education with an allocation of $100 million for the period 2017–2022.

Grants from Strategic Alliances

Grants from strategic alliances augment government funding and reduce reliance on the public sector. These include contributions to an NRIC's foundation, focused investments to cover specific costs or expand scope, and research grants for scholarships and programs. The Alan Turing Institute has made extensive use of grants from academic and private sector strategic alliances.

EXHIBIT 4 | Five Funding Sources NRICs Can Consider to Set an Example for Financial Sustainability



Collaborative Research

As described earlier, NRICs and the academic or private sector often join forces on specific research programs. Collaborative research enables NRICs to share R&D costs and leverage partners' resources.

Such partnerships are part of a global trend. Over the past 10 years, companies have been moving their R&D closer to universities and knowledge hubs. In 2012, P&G invested $300M to build a massive R&D center near University of Cincinnati and transferred more than 50 of its research jobs on-campus. In 2015, Google moved its machine learning research hub from San Francisco to Pittsburgh, close to Carnegie Mellon University which ranks #1 in machine learning programs worldwide. In 2016, GE transferred its world R&D headquarters along with 600 tech-oriented research and development jobs to MIT's Kendall Square.

Corporations are shifting from observing to initiating early stage research. This may take the form of a company funding PhD candidates or Postdoctoral, or having its scientists or engineers co-mentor academic researchers. If something promising emerges, the company provides more funds, directly or through a proposal to government. For example, Boston University partnered with Philips Healthcare to co-fund PhD students on projects related to acute care. Philips Healthcare mobilized more than 20 senior R&D engineers to co-mentor the doctoral students. When promising results started to emerge, the partners submitted a joint funding proposal to the US National Institutes of Health. Co-funding is increasingly taking the form of master agreements rather than one off projects, signaling longer-term research collaborations, with the BU / Philips Healthcare partnership as one example.

AI Singapore's 100Experiments program aims to address industry AI challenges through a tight collaboration between the research center and the private sector. Projects are selected based on three criteria: solution can be quickly built with existing AI knowledge; a minimum viable product can be reached within 9 months; and the solution must be scalable to the entire world. AI Singapore provides up to $250,000 per project to pay for research assistants, PhD students, and/or post-docs, and each project sponsor matches this funding 1:1 in-kind or in-cash. The result is a win-win, with sponsors accessing specialized research capabilities and solutions to pressing challenges, while AI Singapore develops nationally or globally scalable AI-driven applications.

Technology Commercialization

Technology commercialization converts NRIC research into tangible applications and monetizes it through licensing patents or receiving royalties. There are three common models for this type of commercialization. The NRIC can establish a technology transfer office to develop and manage licensing agreements with private sector companies. Alternatively, it can create a venture fund and directly invest in startups originating from its research. Finally, it can form a holding company to push center-generated IP from concept to solutions. We use university examples below, as they pioneered the kinds of research commercialization most relevant to NRICs.

Technology transfer office

This business model generates cash flows through licensing and royalties. It is the lowest risk option, with potential issues mitigated through IP protection contracts. Stanford and MIT both have technology transfer offices. Stanford's Office of Technology Licensing (OTL) supports researchers in structuring patent, copyright and tangible research property agreements with private sector companies. Since 1970, OTL has reviewed over 10,000 invention disclosures and completed over 3,500 license agreements which have generated $1.77 billion in royalties. After deductions to support OTL's operation and reimburse any direct expenses, the net royalties are split equally between the inventor(s), their department and the university.

Venture fund

These operate like a private sector venture capital fund, providing financing and investment to promising NRIC-originated startups. Their goal is to exit successfully at a profit after a specified period of time. One example is the New York University Innovation Fund, which invests exclusively in start-ups founded by, and/or commercializes technologies and intellectual property developed by current NYU students, faculty, and researchers. It makes approximately five to six investments per year, of approximately $0.1-$0.2 million each, and seeks to exit within 3 to 8 years. Since its establishment in 2010, it has financed 70+ start-ups.

Holding company

These holding companies incubate new ventures, owning shares and participating in their management and decision-making. The Oxford Innovation company, a wholly owned subsidiary of University of Oxford, offers a wide range of incubator services. These include business training programs, networking activities, marketing support, accounting / financial management, access to bank financing, angel investors and venture capital, commercialization assistance, IP management, and more. Started in 1987, Oxford Innovation has helped over 7,000 start-ups become sustainable businesses.

Services Commercialization

In addition to commercializing products, an NRIC can monetize services and activities like certifications and training. Low variable costs mean a significant upside opportunity for the NRIC. The Alan Turing Institute offers doctoral training as well as executive education courses for industry, public sector, and third sector leaders. These target practical skills and the latest scientific developments in data ethics, machine learning, and artificial intelligence. AI Singapore, as another example, charges application fees for its AI certifications.

Establishment

Fast execution, as well as ability to attract and retain world-class talent are essential for NRICs' success.

Fast execution requires committed, senior-level government sponsorship. KSA's National Center for AI, for example, is linked to a highly empowered authority whose board reports directly to the country's top leadership. Establishment and scale-up can also be accelerated via long-term Build-Operate-Transfer strategic partnerships. In these instances, a strategic partner builds up the NRIC, runs it for a period of time while developing the center's capabilities, and eventually transfers responsibility back to the NRIC for ongoing, independent operation.

Attracting and retaining research superstars is a critical driver of NRICs' success but also one of their greatest challenges. Top emerging technology experts are among the planet's most popular professionals and already showered with opportunities. However, several best practices can help overcome the recruiting and retention dilemma:

- **Make government data fully available and ensure research independence.** The Alan Turing Institute provides its research fellows with access to government datasets which would otherwise be off-limits. The center does not impose top-down research scope or influence how the findings are published. It simply provides high-level guidance on priority topic areas, and leaves researchers to decide how studies are conducted and socialized.

- **Secure a core founding team of research superstars to create a magnetic cluster of talent, and establish a flagship strategic alliance with a renowned emerging technology player.** One example is the team that Alan Blake, formerly Microsoft Distinguished Scientist and the Laboratory Director of Microsoft Research Cambridge, assembled as the first director of the Alan Turing Institute. Similarly, Fred Moavenzadeh, previously Director of the Technology and Development program at MIT, attracted other top researchers when he was appointed to lead the Abu Dhabi's renewable energy focused Masdar Institute.

- **Borrow best practices from the private sector to develop and retain young talent through special programs such as fellowships, internships, student mentorship and scholarships.**

PRIVATE SECTOR TALENT BEST PRACTICES

Microsoft Research – Internships

Microsoft Research hires 1,000+ students annually as part of internship program – approximately one intern for every full time employee!

Facebook Research – Student Mentorship

Facebook researchers mentor and support university students on projects led by their schools' principal investigators.

Google AI – Scholarships

Google awards scholarships to top AI students to study in international universities, with an eye to hiring them upon graduation. The company has 7 scholarship programs which focus on promoting diversity.

"Top emerging technology experts are among the planet's most popular professionals . However, several best practices can help overcome their recruiting and retention dilemma"

Countries are recognizing the importance of new technology investment to foster social good, economic growth, and resiliency in the face of disruption. COVID-19 has starkly highlighted how countries can leverage technology to predict and address crises – for example, using AI to identify outbreaks and predict their pattern, and China's screening of potentially contagious individuals through computer vision.

Countries wanting to lead or carve out targeted niches in emerging technology fields should consider establishing one or more National Research and Innovation Centers.

Scope will depend on the country's technology priorities and aspirations, as well as its current research and market structure. Does it already have a robust emerging technology strategy, or will that need to be developed? Who are the influential players in the field? To what extent do current efforts benefit from scale, focus and coordination?

Establishing the right relationships will be essential, as collaboration across public, private and academic sectors is central to executing an NRIC's mandate. From these alliances will flow leading-edge research, funding, innovative solution development, and commercialization opportunities. Fast execution, the right sponsorship, and attraction of world-class talent will further ensure long-term relevance and success.

We focus here on how governments can seize these opportunities through National Research and Innovation Centers. However, many of the principles can also apply to how private sector entities approach the design, structuring and execution of targeted innovation strategies.

With many emerging technologies poised to transform every aspect of our lives and presenting rich opportunities for both research and application development, the time to act is now.

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