

A background image of a financial candlestick chart with a grid. The chart features blue and orange candlesticks, a red dashed trend line, and a blue solid trend line. A white arrow points down from the top, and another white arrow points up from the bottom. The number '187.12' is displayed in orange text. The overall color scheme is dark blue and orange.

C21st Science Policy

Focus on: R&D Funding

About UCL

UCL is one of the world's leading multi-disciplinary universities, with students from over 150 countries and more than 13,000 staff.

Founded in 1826, UCL was the first university in England to welcome students of any religion and to welcome women on equal terms with men.

The UCL Department of Science, Technology, Engineering and Public Policy (STEaPP) mobilises science, technology, engineering and policy expertise to help change the world for the better.

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Methodology

The content of this report is drawn from multiple sources and we have used a combination of corresponding data collection and analysis techniques. These included a review of international academic and grey literature on science policy, policy design, and R&D policy instruments; interviews with senior individuals with first-hand experience of the design of national science policy; and multiple trends analysis discussions with the UAE Office of Advanced Sciences team. The research team also benefited from parallel engagement with the staff and experts engaged in the Emirates Mars Mission at the Mohammed Bin Rashid Space Centre. The team has also drawn on findings from previous research. Further details, including the accompanying technical reports, can be found on the UCL Department for Science, Technology, Engineering and Public Policy website (www.ucl.ac.uk/steapp).

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Science Policy for the 21st Century

“

Sustained engagement between scientists and policy makers builds relationships and insights across boundaries. It means the selection of issues, the investigations and the findings are better informed and have more impact.

”

Dr Claire Craig
Director of Science Policy
Royal Society
2016–2019

Developing Science for UAE's Future

Since its independence in 1971 the UAE has implemented a set of development strategies leading to its emergence as a significant oil-based economic power. Over the decades since, its economy, society and culture have evolved significantly. Large-scale investment in national economic development and infrastructure has transformed UAE society. A concern of UAE leaders today is to create sustainable pathways to long-term prosperity and security for Emirati citizens and residents. Science is seen as integral to this ambition, and is recognised as a springboard for the next phase of national development and diversification.

The UAE Office of Advanced Sciences (OAS) is undertaking a series of studies to define and develop opportunities in support of this national ambition. These studies are forward-looking, yet grounded in acknowledgement of UAE's current development profile and its existing knowledge infrastructure and governance configurations. There is considerable domestic momentum behind UAE activities to use science to further national development. In reflecting on similar experiences elsewhere, it is also recognised that the timing of this development is critical. The coming years are likely to be particularly important for developing and embedding science policy to align with and bolster broader national activities and goals.

Science Policy and Leadership

Formulating science policy to maximise the benefits for society is a multidimensional and complex endeavour. Research on the process, boundaries and substance of science policy has undergone various paradigmatic shifts in recent decades. Recent thinking has emphasised the importance of embedding of desired economic and social outcomes within science policy design. Not all science and innovation lead to positive outcomes, however, and a high priority is therefore placed on policy's ability to drive science into positive directions and mitigate against negative consequences.

The UAE's work on conceptualising and implementing science and innovation policy and on promoting science as part of broader culture has much to offer not only to domestic development, but also to wider global learning in this domain.

Science Policy Focus, Capabilities and Boundaries

A science policy designed to advance social and economic capacities pursues several outcomes. First, it has to foster R&D and innovation, and it has to facilitate the production of high-quality outputs from research activity. Equally, it must explore the diversity of pathways between production and uses of science. For this, it needs to foster broad engagement and intermediary capabilities. The building of scientific capacity therefore spans a range of management, engineering, natural, physical and social science skills, responding not only to the needs of individuals, but also organisations and institutions.

This means that in practice science policy needs to foster competence at least three crucial areas:

- I. The funding of science and research relevant to national context, need and ambition
- II. Human intellectual capital to advance the full span of capacities and capabilities required for a competitive science economy
- III. Institutional capacities to join up networks across domains and drive complex and multidimensional initiatives and missions for lasting impact.

This Report

This report results from a joint endeavour between the Science, Engineering, Technology and Public Policy (STeAPP) department at UCL and UAE's Office of Advanced Sciences (OAS). UCL is a world leading university with strengths across a wide range of disciplines and domains. Founded in 1826 with a history of radical thinking aimed at transforming society through knowledge production and engagement, the university has its roots in a quest for progressive public policy.

STeAPP is based in UCL's Engineering Faculty. The department develops new knowledge infrastructures to produce and disseminate expertise for the benefit of society. STeAPP's teaching, research and engagement activities integrate knowledge from diverse social, scientific and technical domains and from academic and practitioner communities. With clear-sighted analysis STeAPP builds new policy insights, capabilities and communities to enhance the societal benefits of investment in science, technology and engineering.

In line with STeAPP's broad ambitions, over the period of April-September 2019, a team of staff members worked with the UAE's Office of Advanced Sciences. Together we explored recent thinking about the design and content of science policy, and the process associated with generating policy for integrating science, technology and innovation with societal aims and ambitions.

This report is a synthesis of that exploration and is based on multiple meetings with the UAE Minister of Advanced Sciences, her team, a range of stakeholders and global experts. It also reflects a targeted desk-based exercise to gather relevant evidence from around the world. The report therefore is broad, covering considerable intellectual breadth and depth. It is designed to give insight into collective analysis about the process and direction of science policy development in the UAE. What this report does not provide is a comprehensive analysis of specific policy instruments, nor does it propose recommendations for specific policy design. Work underpinning this analysis will be published separately. We present our summary in 3 parts:

- I. **Global Science of Science Policy** offers a short summary of the global state of knowledge and best practice regarding the framings and tools used for science policy design.
- II. **7 Principles for UAE Leadership** outlines a set of guidelines with which to shape science policy instruments for the UAE's future.
- III. **Focus On: R&D Funding** draws on these principles in presenting some of the considerations for designing UAE research and innovation funding policy instruments.





Global Science of Science Policy

“

Rapidly emerging economies must develop STI policies that reflect their particular and unique context. In general, countries cannot do everything in science. Their funding systems, goals and policies must therefore reflect a very strategic and contextualized perspective.

”

Sir Peter Gluckman
Chief Science Advisor
New Zealand
2009–2018

What is science policy?

Science policy provides the mechanisms by which public resources are allocated for the conduct of science. This covers multiple domains and a wide range of activities, including fundamental research (enhancing the understanding of phenomena via breakthroughs), applied research (the application of scientific knowledge to practical advances such as technologies), and their connections into commercialisation and marketisation. The latter two areas are the focus of innovation policy; science and innovation policy are highly interconnected policy domains through value chains, institutions, and skilled personnel. Within the umbrella of science policy, there will be multiple constitutive areas of policy instruments, such as the management of funding for research and development (R&D), human intellectual capital, research infrastructure and facilities, intellectual property laws, and more.

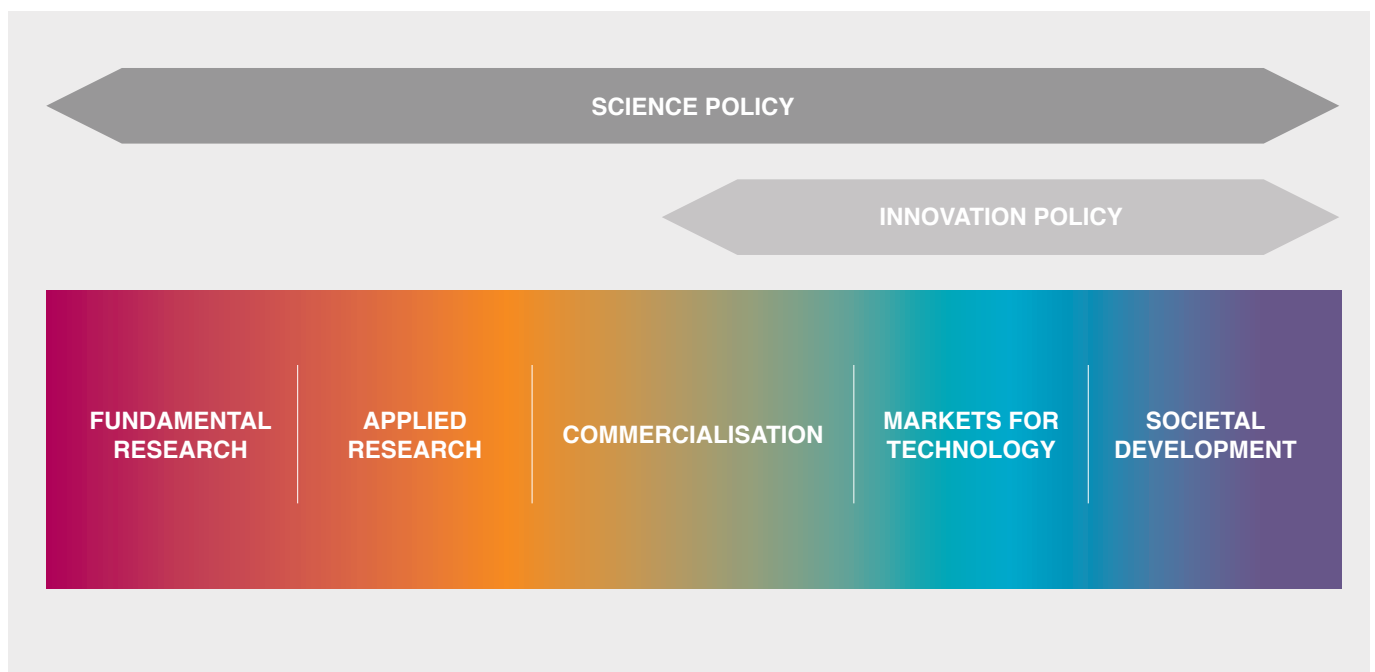


Figure 1. Science and innovation policy are deeply interconnected and span multiple activities

Global Evolution of Ideas

Three frameworks for science policy have evolved sequentially over the past century and have shaped national science policy across the world. They each comprise distinct sets of beliefs about the appropriate roles of actors such as the state, private industry, academia and consumers in enabling good science, as well as provide the justifications for different agendas of policy action. An understanding of the differences in their framing is valuable in setting a nation's science policy agenda.

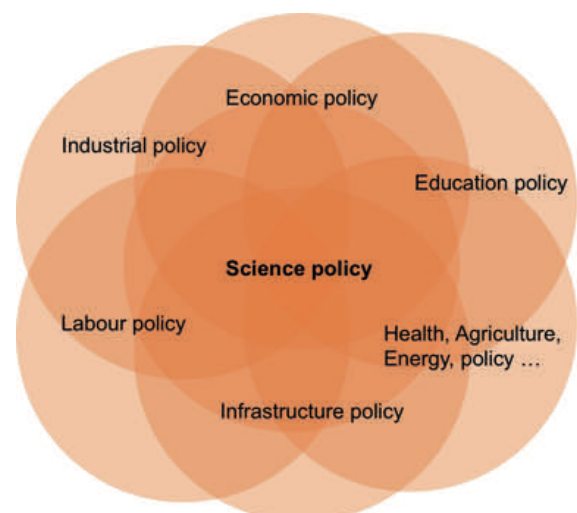


Figure 2. Science policy interfaces closely with other policy areas

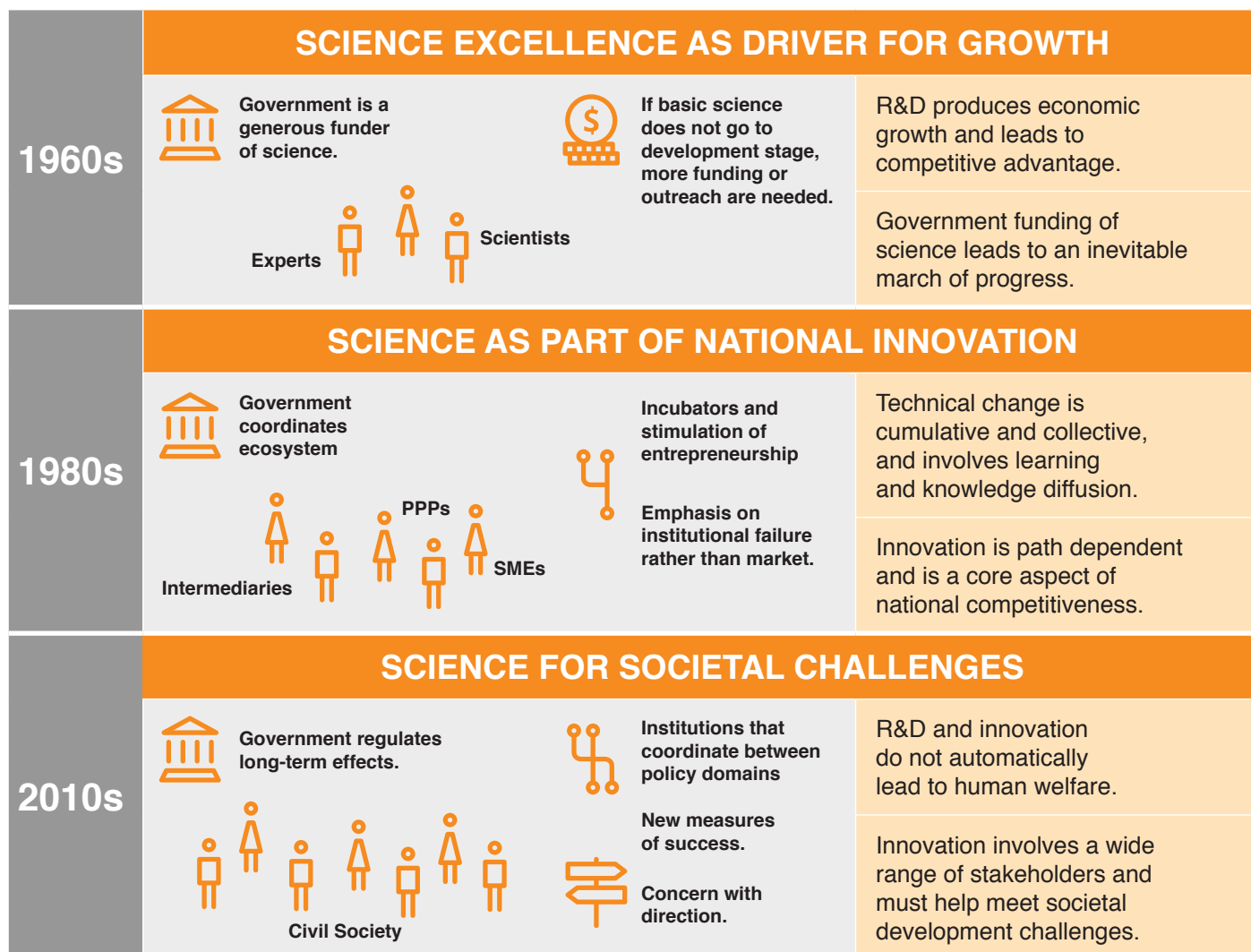


Figure 3. Global evolution of frameworks shaping science policy¹

Knowledge for Integral Design

What has been learnt about how the ideas above are translated into practical decisions and processes, and about how we can do this type of policy design? The field of the science about science policy itself is relatively young. Much of the body of research in this area has largely focused on either the efficacy of individual policy instruments, or one particular dimension, such as the governance of science policy development. Policy officials looking to structure their processes need a means of navigating and framing the knowledge that they have available to them and mapping the knowledge that they require. We identify three strands of requisite knowledge, covering:

- I. **Policy practice.** This is knowledge about the practical processes involved in policy development, including insights about the suitability and effectiveness of different tools for design and analysis, the needed skills and related capacities, and institutional compatibilities.
- II. **Policy content.** This is knowledge about the nature of different policy instruments and the choices that shape the details of their design.
- III. **Policy context.** This is knowledge about the particular context within which the policy will be implemented. This includes knowledge about its purpose, constraints, possibilities and other considerations such as local cultural, social and economic factors.

¹ See Schot, J. and W. E. Steinmueller. 2018. Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, 47(9), pp. 1554–1567.

These sets of knowledge should not be treated as separate strands that are the responsibility of different professionals or individuals. Instead, integral science policy design considers them simultaneously, and reflects their mutual interrelationships within any design processes employed.

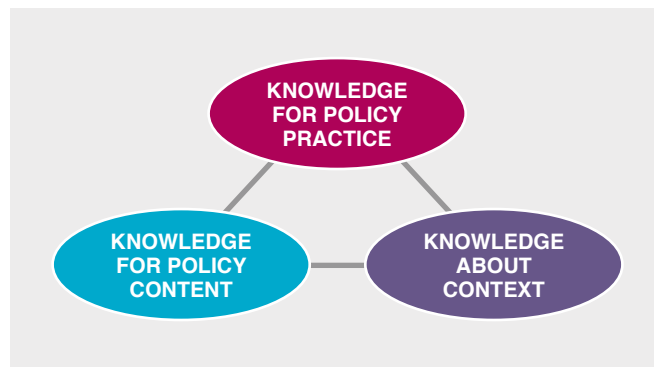


Figure 4. Three types of knowledge for integral science policy design

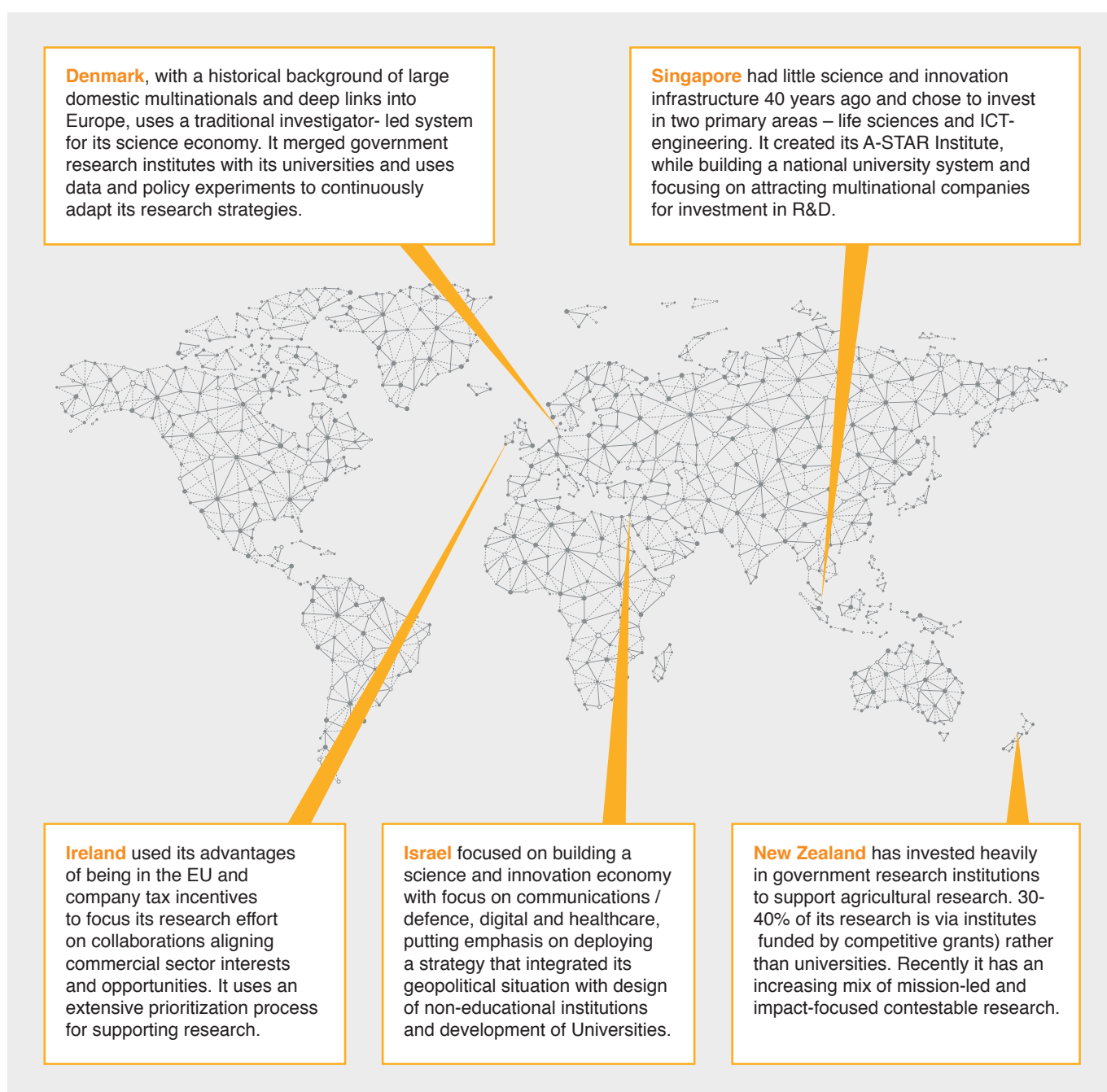


Figure 5. Small countries, substantial science footprints

7 Principles for UAE Leadership

“

Before you talk about funding allocation, you need to talk about the ‘what is it for?’ ‘What is the overarching rationale?’

”

Prof Graeme Reid
Head of Research Funding
UK Government
2016

Global experiences and expertise suggest that while there is no blueprint for science policy formulation, there are shared lessons that can inform its process of design. For the UAE to provide leadership in science it is recommended that its future policies and instruments draw on these lessons as a set of guiding principles enabling successful science policy design.

Avoid Pitfalls of Policy Transfer

Some countries have sought to emulate the research and innovation success of other nations such as the USA and the UK with direct policy transfer and adoption. However, experience cautions strongly against direct replication of the design of a science policy instrument. Direct transfer does not recognise the importance of local context. In particular, science policies often seek to influence particular 'tipping points', and so their underpinning rationales are typically not directly scalable other economies. A 'copy-paste' approach in policy learning and transfer also risks abandoning indigenous strength, and fails to consider the distinctive requirements of local long-term capability development.

Shape with Distinctive Context

Closely related is the principle that science and innovation policies need to explicitly reflect the nature of their particular context. Small advanced economies have historically often outperformed large economies in important respects. Research to explain this has shown that the science policy of small advanced economies often very explicitly considers local strengths, constraints and consequences of risk exposure to disruptions – and subsequently generates more suitable, effective and robust policy outcomes. Policy proposals for new UAE science instruments should therefore demonstrate the logic regarding their fit with the distinctive, local context and play to its particular strengths.

Use Forward-Looking Evidence

In order to craft relevant, locally-suited policy, the evidence used for its design needs to be forward-looking. When primarily backward-looking analysis is drawn upon, a policy's capacity for desirable future impact is significantly weakened. Many of the tools commonly used in analysis for policy design (e.g. historical trends and current state benchmarking), however, produce little useful futures evidence. Widely recognised guidance or standards for assuring the forward-looking quality of an evidence base is currently limited. To bridge this gap, [Figure 7](#) offers a checklist of 'Future Evidence Requirements'. These requirements offer a checklist for primary assumptions made about the future that can be tested using insight from relevant evidence gathered about the following factors that explicitly or implicitly shape proposals: the goals; driver of change; options; pathways; and possible constraints and disruptors shaping a policy proposal.

Make Explicit the Rationale for Change

The logic structuring a particular policy formulation should be clearly articulated in order to provide the basis for any justification of its adoption. By detailing what problems are to be addressed and providing a clear rationale of how the critical mechanisms of change are to be activated alongside what actions and under what conditions, a policy's likely outcomes can be more accurately assessed. This also enables other actors more broadly in the science policy system to quickly understand how their actions might be influenced by a new policy.

Explore Robustness in Outcomes

Robustness refers to the desirable design quality trait where policy maintains functionality despite changing conditions. To achieve this, key assumptions made first must be made explicit (see [Figure 6](#)). The implications of any variation in the state of these assumptions is then tested across alternative futures. A common way to structure such a stress-test exercise is to frame a set of 'what if...?' questions (e.g. 'What if policy goal A changed?' 'What if this critical agent's agenda changed?' 'What if market mechanism B was disrupted by a global event?'). In cases where the same what-if questions are then applied to alternative proposals considered for a policy intervention, such conceptual simulations clarify the trade-offs between them, and enhance the rationale by which a particular policy design or instrument is chosen.

Design for Modularity

Another mechanism for ensuring robustness in policy design is to use a modular architecture where policies are framed with their own coherent logic, but give attention to interdependencies with other policies. Each policy proposal must justify the mechanisms by which it joins into the wider policy ecosystem, but remains robust to any potential changes elsewhere in that ecosystem. This is particularly legitimate for science policy where many overlapping subjects and policy concerns come together, such as human capital, funding and science infrastructure. Modular design enables evolving, dynamic and experimental use of different policy instruments.

Utilise Design for Building Capacity

Policy design as a process has the potential to result in content-driven outcomes such as new ideas and policy formulation, but can crucially also act as a collective learning process for the actors contributing to it. By intentionally structuring policy design processes in a participatory way from the outset, that learning enhances not only the substantive and procedural capacities of those directly involved in the policy team, but also those of actors more widely across the national science system.



In order to enhance the use of forward-looking evidence and explore robustness in outcomes, we benefit from 3 stages of activity:

- I. **To unpack** some of the different types of forward-looking evidence that there can be to inform policy design. (See figure 6 for the 'Futures Evidence Landscape')
- II. **To review** what assumptions are being made about the state of available futures evidence underpinning a new policy proposition (See Part 1 in figure 7 for the 'Futures Evidence Canvas').
- III. **To enhance** the robustness of these assumptions made by considering 'what-if' these assumptions changed? What implications would this have for the performance of our policy and its consequences. See Part 2 of the 'Futures Evidence Canvas', figure 7).

I. Unpacking of forward-looking evidence

The evidence base for future policy content spans three domains: 1) the first provides evidence of the assumptions made about the direction pursued with a policy; the second contains assumptions about the behaviour of the wider system within which policy will operate; and the third provides us with intelligence about different pathways for action that can be pursued. Within these categories are 10 more specific types of future evidence that can be elicited and analysed.

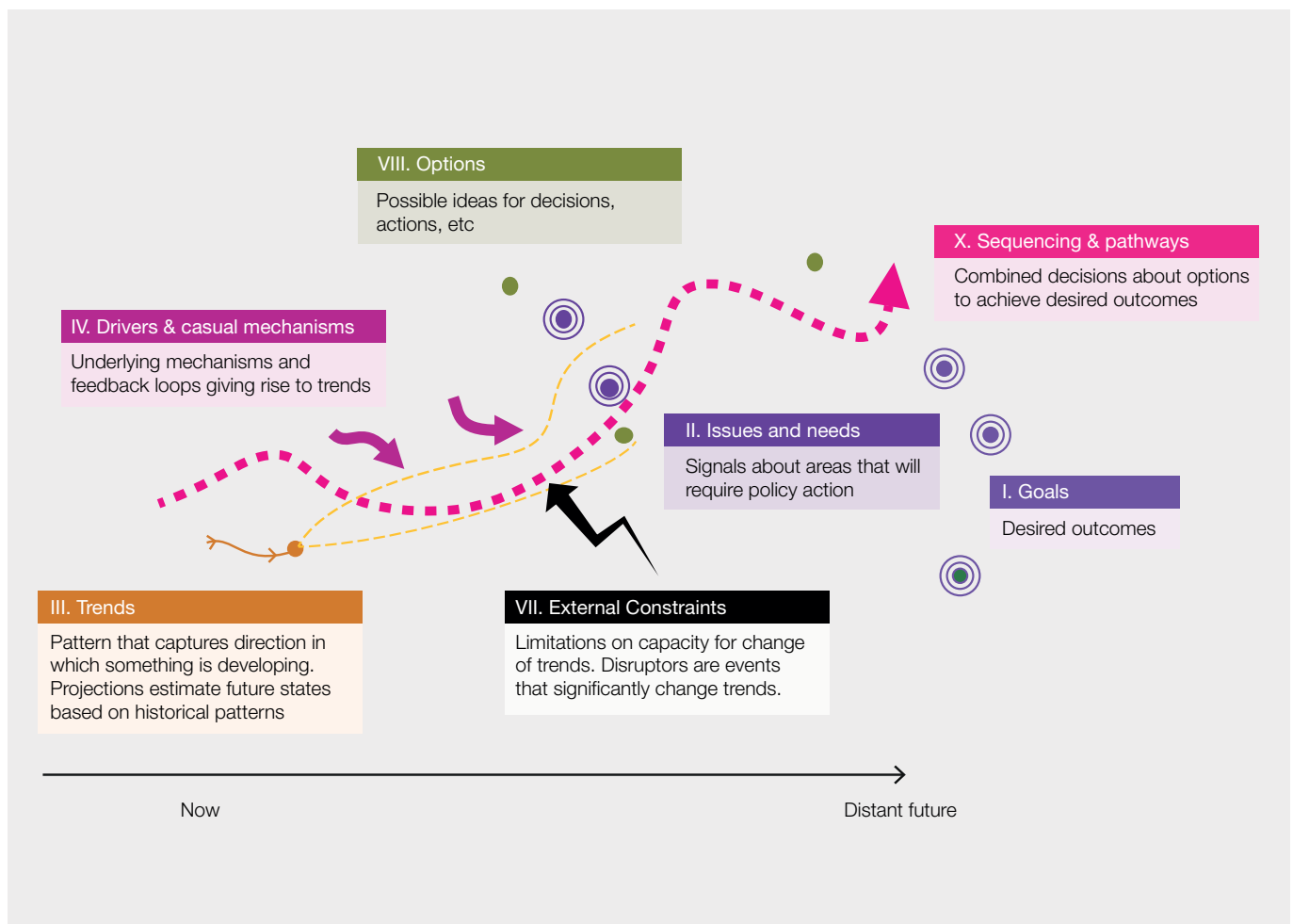


Figure 6. Future Evidence Requirements

II. and III. Reviewing and enhancing the forward-looking evidence base

By systematically considering the state of assumptions made about the futures evidence landscape underpinning a new policy proposition, we can rapidly assess the comprehensiveness of the evidence base.

Future Evidence Type	Guiding question to explore requirement
Setting direction	<i>Where do we want to head?</i>
I. Goals	What do we know about the specific outcomes being pursued? Priorities? Values?
II. Issues & needs	What is the problem we are seeking to resolve? What are the needs to be addressed?
Understanding system behaviour	<i>What do we believe about how the world behaves and will behave?</i>
III. Trends	What are the patterns associated with the development of factors of significance? What is the difference between historical and projected patterns?
IV. Drivers & causal mechanisms	What will drive behaviour of the science policy system? What causal relationships and feedback loops of influence exist?
V. Structures & relationships	What are relevant elements of the science policy system? (e.g. policy structures, institutions, economic, legal, etc). What are the relationships between them?
VI. Agents & agendas	Who are the key agents and actors? What priorities might drive their behaviour?
VII. External constraints	What external constraints will influence possible science policy actions? (e.g. resources, regulatory, etc). What might radically threaten or disrupt the system?
Developing pathways	<i>What do we know about how to move towards our intended direction, within what we know about system behaviour?</i>
VIII. Options	What are possible ideas or decision options for science policy action?
IX. Trade-offs	What are the trade-offs between these?
X. Sequencing	What is known about path dependencies impacting on intended policy action, etc?

Figure 7. Future Evidence Requirements

Focus On: R&D Funding

“

A compelling national vision for science has to link not just a few world-class pioneers but also the thousands of others creating, teaching, adopting and adapting knowledge across all sectors.

”

Geoff Mulgan
Chief Executive
NESTA

The allocation of funding for R&D is a foundational component of science policy. It links the national strategic agenda with the research and translational activities identified as related priorities. It also frames and clarifies the mechanisms by which government targets its support towards the capacities it believes should be developed, with what actors, and within which areas.

R&D funding is arguably the most researched and debated aspect of science policy development. With a view towards the UAE's ambition of developing a globally competitive national science and research base, we present a set of insights and propositions distilled from historic and current experiences globally in formulating R&D funding policy.

Centralised oversight of budget provides government with the critical mass of resource it needs to provide balanced support of science ecosystem. It invests in both cutting-edge foundational science, as well as the translational mechanisms for benefiting of that work – and it does so by rewarding not only the past performance but also future potential of institutions and individual researchers alike.

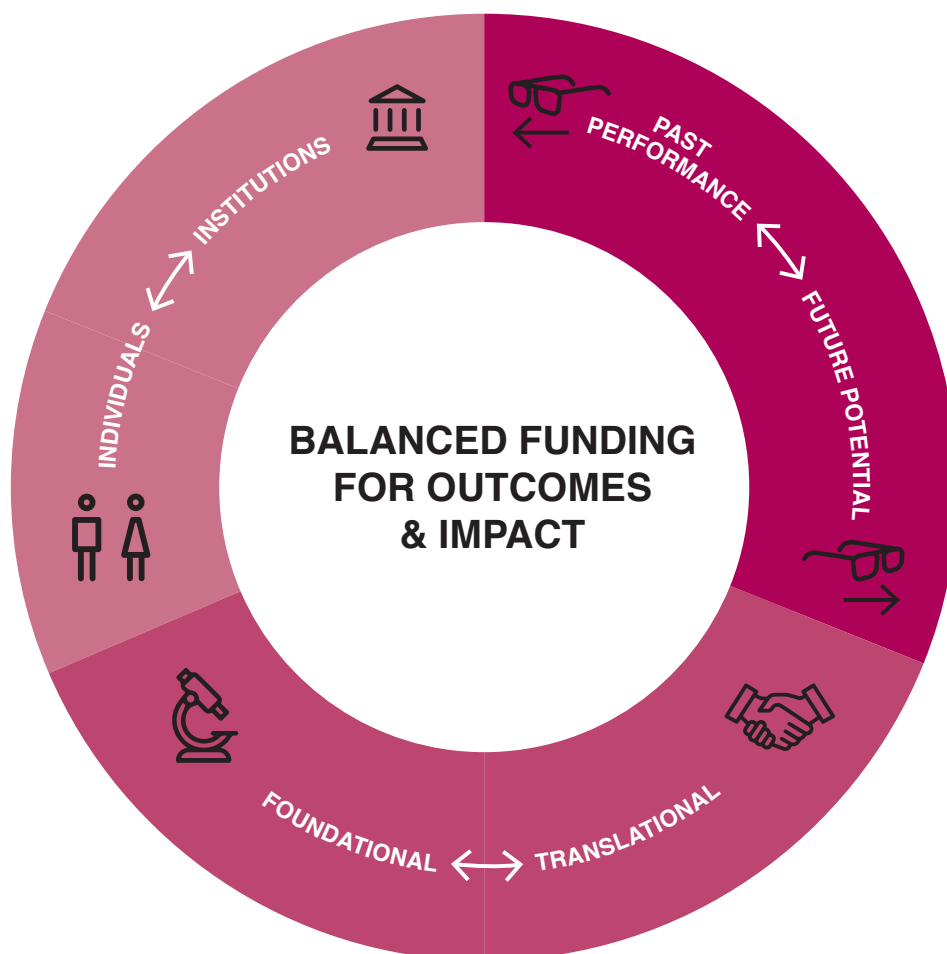


Figure 8. Balanced funding support for research

Pathway for C21st UAE R&D Funding Policy

Science policy development is a dynamic, ever-evolving process. R&D funding policy development follows a pathway throughout that process by drawing connections across a number of critical aspects of that shape the UAE's vision for global leadership in science.

DATA ABOUT SPEND

Data For Insight

Data on what funds are being spent where, on what activities, and to which recipients is essential for oversight of the state and health of the national science system overall. It also offers more granular insight into what areas might benefit from alternative modes of support. Without a consolidated evidence base of total and disaggregated spend, future developments of the mechanisms for transparency and scrutiny will be restricted.

Different systems exist for reporting and accounting spend. In experiences where spend on science is reported separately from other ministerial and departmental spending, this has been used to enable R&D funding allocation mechanisms that reward and incentivise improved efficiency (*further discussed below*).

OVERSIGHT OF BUDGET

Systemic, Coherent & Lean Oversight

Governments then need to integrate their knowledge of the state of spend with oversight of needs for funding. They need to make decisions about the size of the budget they wish to spend on science and research, and the mechanisms they will use to allocate that budget.

While the size of the UAE science budget is set by the Ministry of Finance, mechanisms for oversight and allocation are distributed across a number of departments. There is currently no centralised body in the UAE that uses oversight of a science budget to coordinate all science activities. In part this derives from the messy reality that science is not a single policy programme, but a domain that spans a number of ministerial portfolios.

Dedicating a Budget for Science

In models where the spend and budget for science are overseen by one department or body, 'ring-fencing' mechanisms can be used to fix yearly spend on science and research. This can protect the budget against cuts following wider government spending reviews. It also encourages actors to have confidence in the viability of developing R&D programmes that can draw support of that stable ring-fenced budget. Internationally, it signals to investors that relationships with a UAE science base are secure and long-sighted.

A dedicated budget also has potential to encourage more efficient use of government spend on science. If efficiency of science activities increases, e.g. through sharing of infrastructure such as labs and technical know-how and expertise, then in some models those cost savings are offered to other activities within the ring-fence.

ALIGNMENT OF FUNDING

Funding National Visions With Science

Science policy is only one component of the national policy ecosystem and is closely interconnected with other major policy areas, such as education and economic policy, and is a major contributor to policy areas such as energy and health. In order to achieve coherent fit with those other areas of national policy, the goals of UAE science policies need to align directly with and contribute to the realisation of the UAE 2071 vision.

Funding for science is, however, about more than aligning subsets of national economic activity with the national vision; what science offers is a lever for achieving the UAE's future national visions. Funding allocated to science and research activities produces multiple types of impact, whether through delivery of breakthrough understanding about key challenges, the creation of new businesses and types of employment, the attraction of investment and other support from international actors, the improvement of public service delivery, or the development of diverse, highly skilled individuals.

However, science cannot be seen as a Swiss Army knife; one tool singularly capable of tackling all of the UAE's challenges. It should, for example, not be treated as substitute for economic and industrial policy, but as a close companion.

Alignment of Science & National Development Goals

Goal-setting is a fundamental aspect of any policy creation process. A practical question concerns the mechanisms that can be employed to ensure that the goals of science policies truly fit and align with the broader national aims. In the absence of well-developed and articulated rationales, it can be challenging to select and prioritise the particular areas of science, technology and innovation that most warrant government funding support.

A popularly employed mechanism to facilitate decision making is one that sets direction not with a set of discrete policy goals, but instead with high-level signposts towards priorities in societal change. This tool for aligning science and national development goals is known as a 'missions-oriented policy'. Where used to align funding, missions extend directionality beyond the articulation of individual policy instruments, and can influence the actions of actors such as universities, SMEs and public services more generally by sending clear strategic signals.

Global experience has shown that small countries with relatively early stage science and research bases often engage more than some of their larger counterparts in overt priority-setting, and allocate a greater percentage of their research funding into research that is framed around national 'missions'. Missions can be understood as having the following characteristics²:

- Bold, inspirational with wide societal relevance
- Targeted, measurable and time-bound
- Ambitious but realistic research and innovation actions
- Cross-disciplinary, cross-sectoral and cross-actor innovation
- Multiple, bottom-up solutions.

ALLOCATION OF FUNDING

Catalysing Value Across the System

Beliefs about the value of science are heavily influenced by the image of a linear 'pipeline', in which knowledge contributions from basic and fundamental research are only later translated into economic and societal benefits through distinct processes of applied research and innovation. In this model, it can

ALLOCATION OF FUNDING *(continued)*

seem logical to focus the allocation of funding towards the 'blue skies' end of the pipeline, so that its support is subsequently felt throughout the value generating process.

Numerous studies have shown, however, that in reality the benefits and value generated by science and research activities are much more multi-directional, complex, and closely interdependent through shared human capital.

Spanning Diverse Funding Strategies

A popular rationale guiding government's role in funding R&D has been that in its absence, the private market would underinvest in fundamental research. In this model, government funding for science compensates by prioritising fundamental research activities, which over time result in the inevitable spread and diffusion of the knowledge created, which is taken up by a wide range of actors. Not only are there serious conceptual flaws with this 'trickle down the pipeline' model, but as the UAE context illustrates at times of pressure for short-term outcomes, there can be a preference for government to fund translational research and technology projects and initiatives. The assumption here, based on evidence from a variety of other countries, is that this will fuel the demand for science. In the absence of a large pre-existing science ecosystem, technology-driven science and innovation processes can offer a first focal point for generating heightened research momentum and participation from the private sector.

Funding an Ecosystem, Not a Pipeline

In some contexts, models balancing funding support for pure and applied research across the pipeline model have historically been considered successful (e.g. in medical research funding). The critical limitation for uptake by the UAE of such a linear support model is that it omits the diversity of possible pathways between science research and economic and social development. Instead of a pipeline, science can more accurately be conceived as an 'ecosystem' that generates a multiplicity of benefits along many complicated, interconnected pathways and merits government funding support in multiple places.

Allocating by Impact, Not Type of Research

The models by which funding is allocated therefore need not distinguish between pure, applied or translational science. They instead seek to balance support for individual researchers and institutional contributions, as well as balance the support of prospective promise with reward of historic achievement. For the latter, allocation criteria have typically focused on the input to research (e.g. track record of a researcher), or the outputs of research (e.g. papers and patents). Experiences worldwide have shown, however, that the tactics subsequently adopted by prospective recipients do not necessarily lead to the equally enhanced effectiveness of science.

Instead of focusing on input or output levels, there is increasingly a movement towards the use of funding criteria that focus on both contributions to wider impact and outcomes. This approach to articulating funding allocation criteria demands that those seeking to receive funding need to demonstrate what they would do with it.

FUNDING VIA SYSTEMS

UAE Science as a Global, Open System

Historically, science policy has sometimes treated national science and innovation systems as 'closed' and disconnected from the world beyond. This idea is now widely discredited. Even in cases where knowledge discovery and translation into application happen within a single national context, the infrastructure for catalysing its marketisation can be found located internationally – and vice versa.

This interconnectedness of global science infrastructures for research and translation is of particular significance to the UAE's unique context. With an ambition to rapidly scale up the commercialisation of science, yet also a combination of a nascent research base, absence of taxation and funding bodies (which are the most common instruments used to redistribute the value generated from science), and relatively few relationships between universities and commerce, there is likely an especial strategic role for building partnerships with the necessary infrastructures outside of national borders.

Developing Capacity for Longevity

The capacities needed for an internationally competitive science and innovation base span infrastructures such as equipment and research centres, as well as people with the skills and know-how to undertake scientific research and transpose its outputs into marketable products and services. These capacities have value beyond the duration of individual projects and programmes, and can often offer knowledge transfer into different disciplinary domains.

The skills fostered also enhance the UAE's 'absorptive capacity', which facilitates the import of external developments into the UAE. Global data shows that individuals engaged in research are highly mobile nationally and internationally in their employability. Enhanced national absorptive capacity thereby enhances the relationship between science and industry.

Strengthening With Diversity

That absorptive capacity is strengthened by diversity and plurality in perspectives, skills and experiences. Multiplicity in the perspectives brought into scientific activities enhance insight into the nature of challenges and possibilities for their resolution. Many of the challenges facing the UAE to which science can contribute require contributions from multiple disciplines. Funding allocation should therefore seek to transcend the historically separate treatment of the physical, social, natural and digital sciences, humanities and indigenous knowledge.

Designing Institutions to Match Purpose

The institutional structures required for operationalising R&D funding policies follow the pursued relationships between the public and private sector, as well as choices about allocation, reporting, alignment and capacity sharing mechanisms.

MONITORING VALUE

Monitoring Value

Once funding is allocated, the impacts of its use need to be reported to enable monitoring of value generated. This then both enables scrutiny, as well as the identification and reward of initiatives and actions that led to gains in outcomes (such as the sharing of infrastructure). The design of any monitoring function



**MONITORING
VALUE**
(continued)

faces well-documented challenges of measurement, appraisal, attribution and incentives in a multi-directional, non-linear behaving activity ecosystem.

Moving Past the Pitfalls of Input Metrics

Innovation and the products of research and development can be tracked with input indicators, such as levels of R&D spend, and number of researchers active. This often confuses means and ends, however, as the data suggests expenditure is not necessarily effective in producing good quality research.

Avoiding the Traps of Output Metrics

Publications and citations have been a popular means for appraising the performance of science. The strength in this output metric for monitoring derives in part from its quantifiable and internationally recognised nature. Citation figures risk overinterpretation of performance, as they are not necessarily reflective of quality of research or societal contribution. Another challenge in the use of such output metrics is the time lag between the research activities, their outputs, and eventual publication and citation. When monitoring other output metrics such as patents, licence fees or spinout companies, these metrics have also been criticised for favouring certain types of research that are not necessarily aligned with that of greatest public or economic benefit.

Avoiding the Traps of Output Metrics

For outcome-oriented monitoring, policymakers need to articulate the necessity and relevance of the longer-term effects they wish to from the research and innovation base before the appropriate indicators to track performance can be defined.



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A reputation for impactful science and innovation in an environment with stable funding attracts talent and investment. A virtuous cycle can be initiated where that talent and investment in turn enhance performance, as well as national prestige and reputation. The latter plays a crucial role in unlocking scientific capacity as an effective international diplomacy instrument. The former instils confidence for investment in long-term relationship, and both provide a mechanism by which R&D funding allocation leads to inspiring new talent to participation in the UAE science system.

Directionality and alignment

Many recent global R&D funding policy propositions are premised in ideas about the directionality and alignment of a policy's outcomes with wider long-term goals and development aspirations. How can we measure or assess a policy's fit or alignment with a sense of directionality? Figure 9 outlines the state of current knowledge by which these can be considered.

The alignment of policies can be considered using three lenses:	
Supportive potential	The extent to which the outcomes of a policy supports a given goal or aim.
Conflict potential	The extent to which the outcomes of a policy conflict or counteract with a given goal or aim.
Consistency potential	The extent to which a policy intervention is mutually consistent in governance style with other policies.
The potential for alignment is ideally assessed before the implementation of a policy, when there is not data yet on its performance in practice. While there is no universally preferred means for such <i>ex ante</i> assessment, there are at least three different categories of analytical tools that can be used for this.	
<i>Structural analysis</i>	Policies are typically structured with multiple, interrelated goals. Techniques such as goal modelling, objective mapping, and systems mapping can be used to reveal this networked architecture of a policy's goals, and check alignment with other higher level or comparable level policies' goals.
<i>Behavioural analysis</i>	The effects of policies emerge from their interactions with their environment. Using simulation techniques such as scenario analysis, wargaming and prototyping, the effects of interactions between a policy and other policies and national strategic visions can be identified and explored.
<i>Proxy-based analysis</i>	Instead of exploring alignment of goals themselves, it is possible to explore indicators that act as a compatibility heuristic. These techniques compare the agreement between <i>outcome indicators</i> (such as likely impact on goals on previously defined development goals such as SDGs), <i>policy inputs</i> (such as expenditure in an area that is a proxy for a goal), <i>policy outputs</i> (more direct indicators of the effect of the policy), and <i>policy stance</i> indicators (that are indicative of stated position of the government towards a number of issues) ³ .

Figure 9. Measuring directionality and alignment

R&D Policy Instruments

Instruments are the specific tools used to policy translate R&D funding policy formulation into implementation. There is no single preferable instrument for managing R&D funding. The possibilities span direct funding by government of research (whether for government labs, universities, private actors, etc), to government funding of private R&D (through e.g. grants or procurement), to non-financial instruments such as network-based policies, and information brokerage between different actors. Many nations include a considerable component of tax incentives for private R&D, though within the UAE context of no taxation, this currently holds less relevance.

Though there is no definitive list of R&D policy instruments, it is possible to conceive a taxonomy or 'landscape of options' to inform officials in R&D funding policy design. **Figure 10** offers an overview of this landscape for R&D funding policy instruments.

A final note is that these instruments are typically not used in isolation, but more commonly in combination with others. Little is known though about exactly how the interactions between different policy instruments play out, and there is a whole recently emerging field exploring what data capture on their performance will provide the critical feedback to provide greater insight into this.



3 See King, M., Keijzer, N., Spierings, E. and Matthews, A. 2012. *Measuring Policy Coherence for Development*. Maastricht, The Netherlands: ECDPM.

Government as a ...	Exploring	Framing & Piloting	Scaling & Mainstreaming	
Leader	Foresight & Brokerage Undertake or commission scoping research, host events, broker meetings	Agenda Setting Develop policy strategy around resource allocation	Informing & Coaching Providing how-to support via e.g. start-up hubs, innovation district services	Science Diplomacy Engage within international networks to show-case capacity and attract investment
Customer	Green Papers Commission research on emerging R&D	Standards Establish norms that stimulate new use of knowledge	Procurement (New Tech) Selectively purchase early stage technologies	Procurement (Desired Tech) Purchase desirable yet mature technology
Provider	Test Beds Provide regulatory 'sandboxes' for safe experimentation	Platforms & Clusters Connect researchers and users in localised networks, virtual labs, etc	Public Private Partnerships Arrange cooperative agreements with private sector	Prizes & Rewards Reward impact toward desired outcomes with savings, capital investment, etc
Funder	Direct Funding Funding of exploratory research	Direct Finance Stimulate new thinking to drive future opportunities	Grants & Subsidies Incentivise behaviour change, such as inter-firm R&D collaborations	Public Service Investment Scale up through wider provision of infrastructure and public services
Regulator	Self-Regulation Encourage voluntary codes	Governance Promote ethical standards, transparency rules	Value Protection Safeguard intellectual property	Mediation Enhance practices for cooperation

Figure 10. Diversity of R&D funding policy instruments⁴

⁴ Adapted from the UK Government's Policy Lab 'Styles of Government Intervention'.



Dr Ine Steenmans

Ine focuses on analysis that enhances the future robustness of policies. Her work combines and adapts methods and processes from a wide range of fields, including policy foresight, design, and systems analysis, and seeks to improve their usefulness and usability by policy makers.



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Chris explores how policy makers use scientific evidence. Prior to joining UCL, he spent five years as Director of the UK's Parliamentary Office of Science and Technology (POST). Before that he was the first Executive Director of the Centre for Science and Policy (CSaP) at the University of Cambridge.



Prof Joanna Chataway

Jo has more than 20 years of experience in the areas of innovation and social and economic development – particularly in the analysis and evaluation of investment in research and innovation, including what sorts of instruments translate research into useful innovation.