Institute for Innovation and Public Purpose

Mission-Oriented Innovation Policy: Challenges and Opportunities

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Introduction

Countries around the world are seeking economic growth that is smart (innovation-led), inclusive and sustainable. Such ambitious goals require *re*-thinking the role of government and public policy in the economy. In particular, they necessitate a new justification of government intervention that goes beyond the usual one of simply fixing market failures. Policy in this context is also about co-creating and co-shaping markets—creating different criteria through which to justify, nurture and evaluate public policies.

The ambition to achieve a particular type of economic growth (smart, inclusive, sustainable) is a direct admission that economic growth has not only a rate but also a *direction*.[1] In this context, industrial and innovation strategies can be key pillars to achieve transformational change—in particular, by identifying and articulating new *missions* that can galvanise production, distribution and consumption patterns across various sectors. Addressing such challenges – whether battling climate change or tackling modern care problems– requires investments by both private and public actors.

Reconceptualising the role of the public sector

Mission-oriented public investments are not about de-risking and levelling the playing field, but tilting the playing field in the direction of the desired goals. This includes making strategic decisions on the kind of cross-cutting technological changes that will affect opportunity creation across sectors (eg internet, battery storage), the type of finance that is needed, the types of innovative firms that will need extra support, the types of collaborations with other actors to pursue (in the third and private sectors), and the types of regulations and taxes that can reward behaviour that is desired (eg rewarding long-term investments and reinvestment of profits rather than hoarding).

While public funding has always been important in the early, capital-intensive high-risk areas that the private sector tends to shy away from, modern day missions can provide an even more fervent ground for an ambitious catalytic role for Government in *creating and shaping markets* which provide the basis for private investment.

[1] The direction of innovation was emphasised by Richard Nelson in the 1960s through his NBER work on "The rate and direction of inventive activity" (see: http://www.nber.org/chapters/c2110.pdf), and more recently through the work of Andy Stirling in his work on pathways of innovation. See: Stirling, A. (2008) "'Opening up' and 'closing down' power, participation, and pluralism in the social appraisal of technology." *Science, Technology & Human Values* 33 (2): 262–294

From sectors to missions

Mission-oriented thinking requires understanding the difference between (1) industrial sectors, (2) broad challenges, and (3) concrete problems that different sectors can address to tackle a challenge. Sectors define the boundaries within which firms operate, such as transport, health or energy. A challenge is a broadly defined area which a nation may identify as a priority (whether through political leadership, or the outcome of a movement in civil society). These may include areas like inequality, climate change, or the challenges of an ageing population.

Missions, on the other hand, involve tackling specific problems, such as reducing carbon emissions by a given percentage over a specific year period. They require different sectors to come together in new ways: climate change cannot be fought by the energy sector alone. It will also require changes in transport and nutrition, as well as many other areas.

As industrial strategy makes a return globally, a mission-based approach can help to ensure that industrial policy does not end up as merely a static list of sectors to support. Rather, mission-oriented policies should focus on creating system-wide transformation across many different sectors.

For example, the Apollo mission to the moon required innovation across many different high-tech sectors (eg aerospace) and low-tech sectors (eg textiles). While the mission itself was top down in vision, it was the bottom-up experimentation around solving dozens of 'homework problems', involving different types of partnerships that galvanised the ensuing growth.

Similarly, the *Energiewende* policy in Germany today is a concrete mission with a specific target to reduce carbon emissions over a specific period of time, aimed at tackling a broadly defined challenge (fighting climate change). This has required many sectors, including traditional ones, to transform themselves. The German steel industry, for example, has lowered its material content through transformative policy that required repurpose reuse and recycling activities. While the man on the moon mission was decided top-down via political leadership, the German *Energiewende* policy was the result of bottom-up green movements, which culminated in political understanding and eventually leadership from above. Missions may require consensus building in civil society, combining the need to set directions from above with processes of bottom-up experimentation from below.

Missions around sustainability and green growth will similarly require many different sectors to rethink themselves, and to work together in dynamic and interconnected ways. Amongst other things, this can lead to more 'additionality' in business investment, helping

companies in different sectors to make investments that would otherwise have not been made—extremely important in countries experiencing low business investment.

Risks, rewards and institutional capacity

Investments in industrial transformation, R&D, human capital formation and innovation take time. They involve high risks as there is no guarantee that the investment will pay off. But they are often worth both the wait and risk as they are the key source of productivity-enhancing innovation, creating well-paid jobs and a higher multiplier effect than other types of governmental expenditures.

Crucial to the implementation of a mission-oriented approach to innovation policy is the need to reinvigorate capacity building, competencies and expertise within the state (the 'developmental and networked' entrepreneurial state, as referred to below) such that its different organisations can effectively fulfil their roles in coordinating and providing direction to private actors when formulating and implementing policies that address societal challenges through innovation.

This scoping document outlines the challenges and opportunities of reviving industrial and innovation policies with a mission-oriented lens. This paper aims to spark new thinking around the following:

- the possibilities of using **mission-oriented strategies** directed at solving concrete societal and/or technological challenges;
- the importance of a **systemic approach** to industrial and innovation strategies, and the problems that can result when such an approach is lacking;
- the need to see industrial strategy as an **interaction between multiple actors i**n both public and private sectors;
- the need for decentralised, networked entrepreneurial public organisations to be positioned strategically along the **entire innovation curve** (eg not just upstream in science or downstream in procurement), including the ability to make bold *demand-side* policies that change consumption and investment behaviour;
- ways in which industrial strategy can be used **to direct a green growth agenda**;
- the role **public investment banks** can play in providing **patient long-term strategic finance** to high risk and capital intensive projects, crowding in future business investment.

Grand challenges and 'wicked problems'

The 21st century is becoming increasingly defined by the need to respond to major social, environmental and economic challenges. Sometimes referred to as 'grand challenges', these include environmental threats like climate change, demographic, health and wellbeing concerns, as well as the difficulties of generating sustainable and inclusive growth. These problems are 'wicked' in the sense that they are complex, systemic, interconnected and urgent, requiring insights from many perspectives. Poverty cannot be solved without attention to the interconnections between nutrition, health, infrastructure and education. Grand challenge thinking is being applied both in developed and developing countries, with some of the most interesting experiments around sustainability being driven by the needs of emerging economies.

Mission-oriented innovation and grand challenges

This type of broad-based innovation policy has been called 'mission-oriented' for its aim to achieve specific objectives.[2] [3] It does not facilitate innovation merely by levelling the playing field with horizontal policies that prescribe no direction. On the contrary, such policies, by definition, give explicit technological and sectoral directions to achieve the 'mission'. At the same time, to be successful, they must also enable bottom up experimentation and learning.[4]

Examples of such direction-setting policies abound, including different technology policy initiatives in the US,[5] France,[6] the UK,[7]

[2] Ergas, H. (1987) 'Does technology policy matter', Technology and global industry: Companies and nations in the world economy, pp. 191-245; Freeman, C. (1996) 'The Greening of technology and models of innovation', Technological Forecasting & Social Change, 53(1), pp. 27-39.
[3] Mazzucato, M. (2014) Think Piece: "A Mission Oriented Approach to Building the Entrepreneurial State", paper commissioned by Innovate UK-Technology Strategy Board November 2014T14/165. Available at: https://www.gov.uk/government/news/long-term-growth-innovations-role-in-economic-success.
[4] Rodrik, D. (2004) 'Industrial Policy for the Twenty-First Century', John F. Kennedy School of Government Working Paper Series, rwp04-047.
[5] Mowery, D. C., Nelson, R. R. and Martin, B. R. (2010) 'Technology policy and global warming: Why new policy models are needed (or why putting new wine in old bottles won't work)', Research Policy, 39(8), pp. 1011-1023.
[6] Foray, D., David, P. A. and Hall, B. (2009) 'Smart Specialisation. The concept', Knowledge Economists Policy Brief (Expert group on Knowledge for growth), (9).
[7] Mowery, D. C., Nelson, R. R. and Martin, B. R. (2010) "Technology Policy and Global Warming: Why New Policy Models are Needed (Or Why Putting New Wine in Old Bottles Won't Work)." Research Policy, 39: 1011–1023.

and Germany.[8] These policies were implemented by mission-oriented agencies and policy programmes: military R&D programmes; the National Institutes of Health (NIH);[9] grand missions of agricultural innovation;[10] and energy.[11] In these examples, the organisation made choices on what to fund: opting to tilt the playing field rather than only 'level it'.[12] Thus the 'picking winner' problem, which continues to dominate the industrial policy debate, is a static one that creates a false dichotomy: what is crucial is not whether choices must be made, but how 'intelligent' the picking of 'directions' can be.

The fact that the United Nations has reached agreement across 17 sustainable development goals, encompassing 169 targets, is an opportunity for mission-oriented investments today.

While the literature has focused largely on mission-oriented policies in developed countries, there are perhaps more opportunities in developing countries due to the greater 'challenges' they face. Indeed, mission-oriented policies could be a way for the natural resource curse to be approached: rather than natural resources being seen as belonging to a particular sector, they could be viewed as part of a solution to a greater mission. What are the missions that innovations in precious metals can help address? What are the missions that innovations in biotechnology and agribusiness can address? How can a 'green growth' strategy help address innovations in traditional sectors that must lower their material content?

A second problem (besides ignoring developing countries) is that the literature on mission-oriented policies has not integrated empirical insights to provide a full-fledged theory able to replace the orthodox view of directionless policy. Consequently, studies have resulted in ad-hoc theoretical understandings and policy advice on how to manage mission-oriented initiatives, without tackling the key justifications for mission-oriented policies that contrast those of simply fixing market failures.

In a market failure framework, *ex-ante* analysis aims to estimate benefits and costs (including those associated with government failures), while *ex-post* analysis seeks to verify whether the estimates were correct and the market failure successfully addressed. In contrast, a mission-oriented framework requires continuous and dynamic monitoring and evaluation throughout the innovation policy process.

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[8] Cantner, U. and Pyka, A. (2001) 'Classifying technology policy from an evolutionary perspective', Research Policy, 30(5), pp. 759-775.
[9] Sampat, B. N. (2012) 'Mission-oriented biomedical research at the NIH', Research Policy, 41(10), pp. 1729-1741.
[10] Wright, B. D. (2012) 'Grand missions of agricultural innovation', Research Policy, 41(10), pp. 1716-1728.
[11] Anadon, L. D. (2012) 'Missions-oriented RD&D institutions in energy: a comparative analysis of China, the United Kingdom, and the United States.' Research Policy 41(10), pp. 1742-1756.
[12] Mazzucato, M. and Perez, C. (2015) 'Innovation as growth policy', in Fagerberg, J., Laestadius, S. & Martin, B.R. (eds.) The Triple Challenge for Europe: Economic Development, Climate Change, and Governance. Oxford: OUP, pp. 229-264.

In its most general form, the mission-oriented framework differentiates between public policies that target the development of specific technologies in line with state-defined goals ('missions') and those that aim at the institutional development of a system of innovation.[13] The State must therefore be able to learn from past experiences in mission-oriented innovation policy.

Systemic mission-oriented policies must be based on a sound and clear diagnosis and prognosis (foresight). This requires not only the identification of missing links, failures and bottlenecks – the weaknesses or challenges of a national system of innovation – but also recognition of the system's strengths. Foresight is necessary in order to scrutinise future opportunities and identify how strengths may be used to overcome weaknesses. This diagnosis should be used to devise concrete strategies, novel institutions and new linkages in the innovation system.[14]

Mission-oriented policies can therefore be defined as systemic public policies that draw on frontier knowledge to attain specific goals, or "big science deployed to meet big problems".[15] The archetypical historical mission is NASA putting a man on the moon. Contemporary missions aim to address broader challenges that require long-term commitment to the development of many technological solutions.[16] The active role being taken by the public sector towards renewable energy investments can be seen as a new mission in relation to the green economy. Other new missions include addressing such 'grand societal challenges' as the ageing/demographic crisis, inequality and youth unemployment.[17] In fact, these challenges – which can be environmental, demographic, economic or social – have entered innovation policy agendas as key justifications for action, providing strategic direction for funding policies and innovation efforts.

However, modern missions are more complex because there are fewer clear technological challenges and outcomes are less clearly defined.[18] One could add that these challenges also require changes at the societal/national systems level. The so-called Maastricht Memorandum provides a detailed analysis of the differences between old and new mission-oriented projects (Table 1).

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[13] Ergas, H. (1987) 'Does technology policy matter'; Cantner, U. and Pyka, A. (2001) 'Classifying technology policy from an evolutionary perspective'.
[14] Mazzucato M. (2016a) "From Market Fixing to Market-Creating: A new framework for innovation policy", Special Issue of Industry and Innovation: "Innovation Policy – can it make a difference?", 23(2).
[15] Ergas, H. (1987) 'Does technology policy matter'.
[16] Foray, D., Mowery, D. and Nelson, R.R. (2012) "Public R&D and Social Challenges: What Lessons from Mission R&D Programs?". *Research Policy,* 41: 1697–1702.
[17] European Commission (2011) Green Paper–From Challenges to Opportunities: Towards a Common Strategic Framework for EU Research and Innovation Funding. Brussels: European Commission.
[18] Foray, D., Mowery, D. and Nelson, R. R. (2012) "Public R&D and Social Challenges: What Lessons from Mission R&D Programs?".

Table 1: Characteristics of old and new mission-oriented projects[19]

Old: Defense, nuclear and aerospace	New: Environmental technologies and societal challenges
Diffusion of the results outside of the core of participants is of minor importance or actively discouraged	Diffusion of the results is a central goal and is actively encouraged
The mission is defined in terms of the number of technical achievements, with little regard to their economic feasibility	The mission is defined in terms of economically feasible technical solutions to particular societal problems
The goals and the direction of technological development are defined in advance by a small group of experts	The direction of technical change is influenced by a wide range of actors including government, private firms and consumer groups
Centralised control within a government administration	Decentralised control with a large number of agents involved
Participation is limited to a small group of firms due to the emphasis on a small number of radical technologies	Emphasis on the development of both radical and incremental innovations in order to permit a large number of firms to participate
Self-contained projects with little need for complementary policies and scant attention paid to coherence	Complementary policies vital for success and close attention paid to coherence with other goals

Source: modified version of table 5 in Soete and Arundel (1993, p. 51).

Although the memorandum specifically focuses on mission-oriented programmes that tackle environmental challenges, its analysis applies to other contemporary challenges (water and food supply, energy efficiency and security, disease, demographic change, etc). This is because these challenges all present similar characteristics, particularly that new technological solutions to address them will require long-term commitment from both public and private agents. The diffusion of solutions to a broad base of users is key.

One of the most pressing contemporary challenges is the need for *inclusion* of vast numbers of people in the innovation process and the socio-economic system as a whole, in order to tackle the issue of inequality. A recent and flourishing body of literature has explored the connections between innovation and systems of innovation and social inclusion. Issues of social development are being studied and targeted in policy action under the heading of 'social innovation'. Some missions will address inequality directly, others indirectly. In some cases, complementary investment in infrastructure and skills will be required if innovation policies are to be effective in addressing inequality. A mission-oriented policy agenda would increase the effectiveness of innovation policy and also has the potential to help rebalance public finances, not by cutting expenditures – as in the prevailing austerity agenda (which often

[19] Soete, L. and Arundel, A. (1993) An Integrated Approach to European Innovation and Technology Diffusion Policy: A Maastricht Memorandum, Luxembourg: Commission of the European Communities, SPRINT Programme.

affects the most vulnerable parts of the population) – but by increasing strategic investments that, due to the higher multiplier effect, would increase future revenues.

The six characteristics of contemporary missions identified in Table 1 – diffusion of technologies, economic feasibility, shared sense of direction, decentralised control by public agencies, development of both radical and incremental innovations, and enabling complementary policies – are of pragmatic importance for the promotion and implementation of mission-oriented policies.

A mission-oriented approach highlights the need to make a precise diagnosis of the technological, sectoral, or national innovation system that an innovation policy wishes to transform. The alignment of different types of capabilities is key for the success of any mission-oriented policy. These can be described as:[20]

- **Missions should be well defined.** More granular definition of the technological challenge facilitates the establishment of intermediate goals and deliverables, and processes of monitoring and accountability. When governance is too broad, it can become faulty, and there is a risk of being captured by vested interests.
- **A mission does not comprise a single R&D or innovation project, but a portfolio of such projects.** Because R&D and innovation is highly uncertain, some projects will fail and others will succeed. All concerned should be able to accept failures and to use them as learning experiences. Furthermore, stakeholders should not be punished because of failures derived from good-faith efforts.
- **Missions should result in a trickle-down effect**, whereby the priorities are translated into concrete policy instruments and actions to be carried out by all levels of the public institutions involved. While these missions should involve a range of public institutions, it is crucial that there is a strategic division of labour amongst them, with well-defined responsibilities for coordination and monitoring.

These considerations point to the need to adopt a pragmatic approach to defining missions. Chosen missions should be feasible, draw on existing public and private resources, be amenable to existing policy instruments, and command broad and continuous political support. Missions should create a long-term public agenda for innovation policies, address a societal demand or need, and draw on the high

[20] Mazzucato, M. and Penna, C. (2016a) 'The Brazilian Innovation System: A Mission-Oriented Policy Proposal', Report for the Brazilian Government commissioned by the Brazilian Ministry for Science, Technology and Innovation through the Centre for Strategic Management and Studies, (06/04/2016). Available at: https://www.cgee.org.br/the-brazilian-innovation-system.

potential of the country's science and technology system to develop innovations.

From directed policy to bottom-up experimentation across sectors

> *"The design of a good policy is, to a considerable extent, the design of an organisational structure capable of learning and of adjusting behavior in response to what is learned"*
> ***Richard Nelson and Sydney Winter**, 1982*[21]

> *"[S]hift from total confidence in the existence of a fundamental solution for social and economic problems to a more questioning, pragmatic attitude –from ideological certainty to more open-ended, eclectic, skeptical inquiry"*
> ***Albert Hirschman**, 1987*[22]

To a certain extent, providing a straightforward list of missions for a country contradicts the core element in successful mission-oriented programmes. Missions should be determined through a fine-tuned diagnosis of the problem and solution that involves stakeholders, draws on the strengths of the country's system of innovation and considers ways to overcome its weaknesses. Who decides the mission is a key issue that requires more thought. While the moon-shot mission was to a large extent a top-down mission led by President Kennedy, the effects of the process—many of which are in our 'smart' products today—occurred through the bottom-up interaction between different types of organisations that each took a part of the challenge. The modern day obsession with commercialisation strategies ironically has led to less commercialisation results than those policies that focused less on the result and more on the process. In this sense, mission-oriented thinking can learn from Hirschman's emphasis on 'policy as process' and the need to welcome serendipity and uncertainty – what he called the 'hiding hand'.[23]

The nature of bottom-up experimentation is key. Industrial strategy requires both horizontal and vertical policies working together systemically. Traditionally, industrial strategy often focuses on (vertical) sectoral interventions. Until the end of the 1970s this consisted of various measures ranging from indicative planning to outright nationalisation of entire industries (eg steel, coal, shipbuilding, aerospace and so on).

Although certain sectors might be more suited for sector-specific strategies, there are good reasons for avoiding a sectoral approach – particularly when private lobbying interests may prevail in

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[21] Nelson, R. R. and Winter, S. G. (1982) An Evolutionary Theory of Economic Change. Cambridge (MA): Belknap Press.
[22] Hirschman, A. O. (1987) The political economy of Latin American development: seven exercises in retrospection, Latin American Research Review, vol. 22, No. 3, Washington, D.C.
[23] Hirschman, A. O. (1967) 'Development Projects Observed'. Brookings Institution Press.

negotiating specific provisions with the government,[24] negatively influencing the industrial strategy with indirect measures (eg tax credits) that potentially waste public funds and create little if no additionality in terms of new investment. The patent box tax incentive represents an example of these misconceived policies since there is no reason to lower tax on monopoly profits and it provides little incentive for additional research investment.[25] In countries where business investment in R&D (BERD) continues to be below the OECD average, sectoral policies risk allowing the private sector to continue to ask for subsidies or support, rather than fundamentally transforming themselves.

The case for building a modern industrial strategy on the identification of challenges, rather than sectors, is compelling and increasingly recognised. A mission-oriented approach uses specific challenges to stimulate innovation across sectors. Through well-defined missions – focused on solving important societal challenges related to climate change and environmental quality, demographic changes, health and wellbeing, mobility issues etc – the government has the opportunity to determine the direction of growth by making strategic investments throughout the innovation chain and creating the potential for greater spill-overs across multiple sectors, including low-tech sectors.[26]

Germany's *Energiewende* is a model of how to implement an integrated strategy that addresses several sectors and technologies in the economy and enables bottom-up learning processes. With its missions to fight climate change, phase-out nuclear power, improve energy security by substituting imported fossil fuel with renewable sources, and increase energy efficiency, *Energiewende* is providing a direction to technical change and growth across different sectors through targeted transformations in production, distribution and consumption.

This has allowed even a traditional sector like steel to use the 'green' direction to renew itself. Indeed, German innovation policy has placed pressure on steel to lower its material content through the use of a 'reuse, recycle, and repurpose' strategy.[27]

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[24] Buchanan, J. M. (2003) "Public Choice: The Origins and Development of a Research Program". *Champions of Freedom*, vol. 31, pp. 13-22.
[25] Griffith, R., Miller, H. and O'Connel, M. (2010) "Corporate Taxes and Intellectual Property: Simulating the Effect of Patent Boxes". IFS Briefing Note 112, Institute for Fiscal Studies.
[26] Foray, D., Mowery, D. D. and Nelson, R. R. (2012) "Public R&D and Social Challenges: What Lessons from Mission R&D Programs?".
[27] BMUB (2016) "German Resource Efficiency Programme II". Available at: http://www.bmub.bund.de/fileadmin/Daten_BMU/Pools/Broschueren/german_resource_efficiency_programme_ii_bf.pdf.

Making markets – not only fixing them

The idea that the State is at best a fixer of markets has its roots in neoclassical economic theory, which asserts that competitive markets will bring about optimal outcomes if left to their own devices. This theory justifies government 'intervention' in the economy only if there are explicit *market failures*, which might arise from the presence of positive externalities (eg public goods like basic research, which require public sector spending on science), negative externalities (eg pollution, which require public sector taxation) and incomplete information (where the public sector may provide incubators or loan guarantees).[28] On top of this, the literature on systems of innovation has also highlighted the presence of system failures—for example the lack of linkages between science and industry—requiring the creation of new institutions enabling those linkages.[29]

And yet the recent history of capitalism depicts a different story – one in which different types of public actors have been responsible for actively shaping and creating markets and systems, not just fixing them; and for creating wealth, not just redistributing it. Indeed, markets themselves are outcomes of the interactions between both public and private actors, as well as actors from the third sector and from civil society. Mission-oriented innovation policy in this context is about the creation of new markets, not fixing existing ones—and yet this framework has not yet debunked the market fixing policy framework. Indeed, even the systems of innovation literature has not fully divorced itself from a 'fixing' perspective, as the way it is often interpreted is in terms of fixing system failures (eg formulating the missing links between science and industry).[30]

Systems of innovation

> *"The elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge … and are either located within or rooted inside the borders of a nation state"*

[28] Reviews of the impact of positive externalities and incomplete information on innovation financing is provided in Hall (2002), Hall and Lerner (2009) and more recent evidence is reviewed in Kerr and Nanda (2014). The role for government in the face of negative externalities (climate change) is laid out in Jaffe *et al.* (2005).
[29] Lundvall, B.-A. (1992) 'Introduction', in Lundvall, B.-A. (ed.) National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. London: Pinter, pp. 1-20.
[30] *Ibid*.

***Bengt-Ake Lundvall**, 1992*[31]

Innovation policy is not just about funding R&D but creating systems which allow new knowledge to diffuse across an economy and create transformative change, including increases in productivity.[32] A *narrow* perspective on systems of innovation can be differentiated from a *broad* perspective.[33] The *narrow* perspective is focused on the science and technology subsystem (which includes capacity-building, training and formal education, plus science- and technology-related services) and its relationship with the production and innovation subsystem (where firms mainly operate). The *broad* perspective includes other subsystems and contexts: for example the subsystems of policy, promotion, representation and financing; demand (market segments); and the (geo)political and socio-economic context.

Figure 1 depicts a generic national system of innovation. Each level sustains and influences the other. Although the depiction implies a linear hierarchical relationship, in reality, there are mutual causations and flat hierarchies. Thus, there is no unidirectional causality, for example, from policies or science to market strategies and innovation. Nor is there an implication that any layer or subsystem is more important than others.

At the base of a national innovation system is the socio-economic, political, cultural, and environmental context. The next layer up is the government and state apparatus, which is responsible for public policy-making and funding. This is the subsystem of public policies/regulations and funding. Two other subsystems are the subsystem of production and innovation, which is populated mainly by business firms and their R&D labs, and the subsystem of research and education, which includes research and technology institutions (including universities and public R&D labs, but also other education organisations).

These two subsystems operate on a broad knowledge base, and may collaborate with each other. Firms in the innovation and production subsystem engage in market exchanges selling/buying goods and services to/from consumers/suppliers. Universities and research institutes engage in market exchanges for knowledge and human resources. Both of these subsystems may also draw on financial markets for funding and investments.

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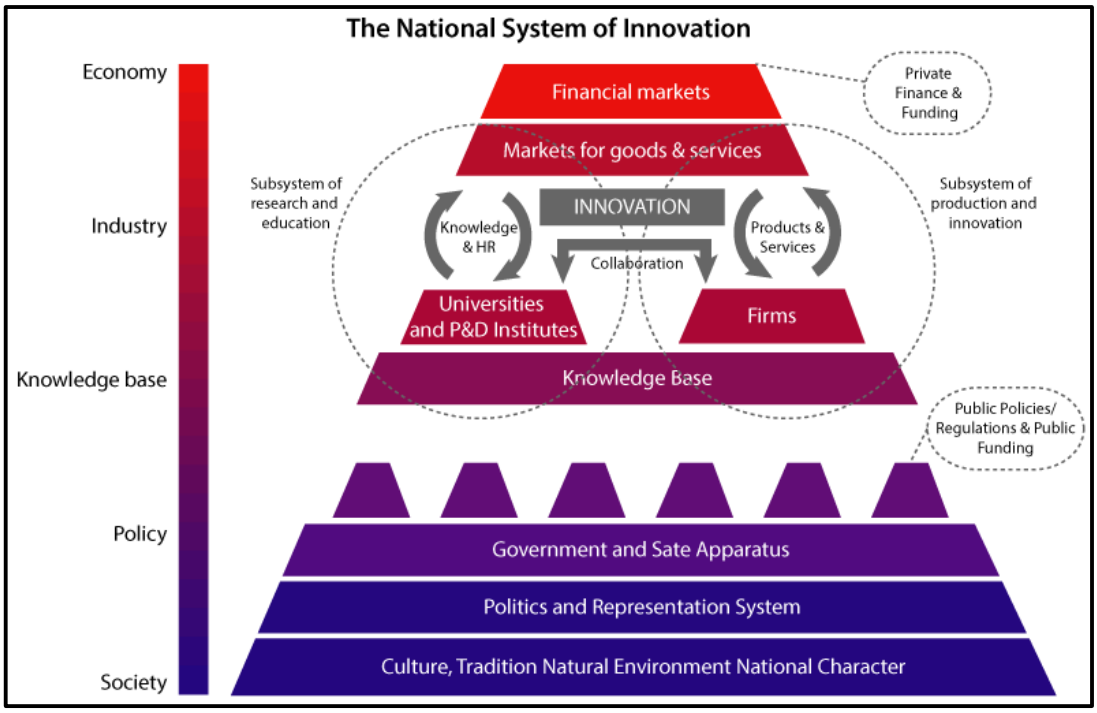
[31] *Ibid*.

[32] Freeman, C. (1987) Technology Policy and Economic Performance: Lessons from Japan. London: Pinter.; Lundvall, B.-A. (1992) 'Introduction', in Lundvall, B.-A. (ed.) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter, pp. 1-20.

[33] Cassiolato, J. E. (2015) 'Evolution and Dynamics of the Brazilian National System of Innovation', in Shome, P. & Sharma, P. (eds.) Emerging Economies: Springer India, pp. 265-310.

Figure 1: Representation of a national system of innovation



Source: figure created by Mazzucato and Penna (2016) based on diagram prepared by the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT, 2002).

Nature of actors and interactions

Systems and eco-systems of innovation (sectoral, regional and national) require the presence of dynamic links between the different *actors* and institutions (firms, financial institutions, research/education, public sector funds, intermediary institutions) as well as horizontal links *within* organisations and institutions.[34] What, also should be emphasised, and has not been thus far in the literature on systems of innovation, is the nature of the actual actors and institutions required for innovation-led growth.[35]

In order to stimulate the innovation process by shaping and creating technologies, sectors and markets, dynamic relationships must be developed which create trust between actors. It is essential in this process for the lead public organisations to galvanise the interests of relevant actors and organise itself so that it has the 'intelligence' to think big and formulate bold policies that create a sense of ownership amongst diverse public, private and academic stakeholders. It is also crucial to be able to implement the policies by coordinating the efforts of this network of stakeholders through the state's convening power, brokering of trust relationships, and the use of targeted policy instruments.

[34] Freeman, C. (1995) 'The 'National System of Innovation' in historical perspective', Cambridge Journal of economics, 19(1), pp. 5-24.
[35] Mazzucato M. (2016a) "From Market Fixing to Market-Creating: A new framework for innovation policy".

Because innovation is extremely uncertain, the ability to experiment and explore is key for a successful entrepreneurial state.[36] Therefore, a crucial element in organising the state for its entrepreneurial role is *absorptive capacity* or *institutional learning*.[37] Governmental agencies learn in a process of investment, discovery, and experimentation that is part of mission-oriented initiatives.

Other authors have referred to this experimentation and learning process as 'smart specialisation'.[38] However, smart specialisation is most commonly used in connection with a market failure framework, meaning that it is seen as a discovery process for the identification of bottlenecks, failures, and missing links (that is, market-failures or market gaps). Smart specialisation would be more usefully employed in connection to a systemic perspective on innovation policies.

Key to mission-oriented innovation is the exploration of the characteristics of innovation agencies that must be in place so that they can welcome uncertainty and build explorative capacity. Breznitz and Ornston focus on the role of peripheral agencies, arguing that when they become too central and well-funded they lose their flexibility and ability for out of the box thinking.[39] While the importance of flexibility is no doubt important, it is also true that some of the most important innovation agencies in Europe and the US were not so peripheral, as can be seen by DARPA's continued success in recent years. What seems to be more important for these organisations is a degree of political independence. Indeed, Italy's public holding company IRI (the *Istituto per la Ricostruzione Industriale* established in 1933) had its most successful phase before the 1970s when it was public. The key lesson is that it is not about public or private, but what kind of public and what kind of private.

A Networked Entrepreneurial State

An entrepreneurial state is not comprised of one ministry or agency calling the shots top-down, but rather by the set of decentralised interactions between different agencies across the entire innovation chain, in turn interacting with private actors. It is this system that has

[36] Hirschman, A. O. (1967) 'Development Projects Observed'; Rodrik, D. (2004) 'Industrial Policy for the Twenty-First Century'; Mazzucato, M. (2013) The Entrepreneurial State: Debunking the Public Vs. Private Myth in Risk and Innovation. London: Anthem Press.
[37] Cohen, W. M. and Levinthal, D. A. (1990) 'Absorptive capacity: a new perspective on learning and innovation', Administrative science quarterly, 35(1); Johnson, B. H. (1992) 'Institutional Learning', in Lundvall, B.-A. (ed.) National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. London: Pinter, pp. 23-44.
[38] Foray, D., David, P. A. and Hall, B. (2009) 'Smart Specialisation. The concept'.
[39] Breznitz, D., and Ornston, D. (2013) "The revolutionary power of peripheral agencies. Explaining radical policy innovation in Finland and Israel." Comparative Political Studies 46(10): 1219-1245.

been at the centre of US competitiveness.[40] This competitiveness is today under potential threat from the US government's cuts to those very agencies.[41]

In *The Entrepreneurial State* these lessons are used to reflect on more general principles, building a market making view of policy.[42] Five key points are emphasised:

- Investment along the entire innovation chain, including demand-side policies.
- Decentralised nature of public mission-oriented organisations (not top-down).
- Risk-taking and investment not only during the downside of the business cycle.
- Long-term strategic finance.
- Equitable distribution of risk and rewards.

Investment along the entire innovation chain

Market failure theory justifies intervention when there are clear market failures, such as when there are positive externalities generated from 'public goods' like basic research. While technological revolutions have always required publicly funded science, often ignored by the market failure framework is the complementary public funds also spent by a network of different institutions further on in the innovation process. In other words, the public sector has been crucial for applied research, as well as for basic research, and for providing early-stage high-risk finance to innovative companies willing to invest. The public sector has historically also been important for the direct creation of markets through procurement policy,[43] and for bold demand policies that have allowed new technologies to diffuse.[44] Thus, Perez argues that, for example, without the policies that led to the growth of suburbs in the US, mass production would not have had the effect it did across the economy.

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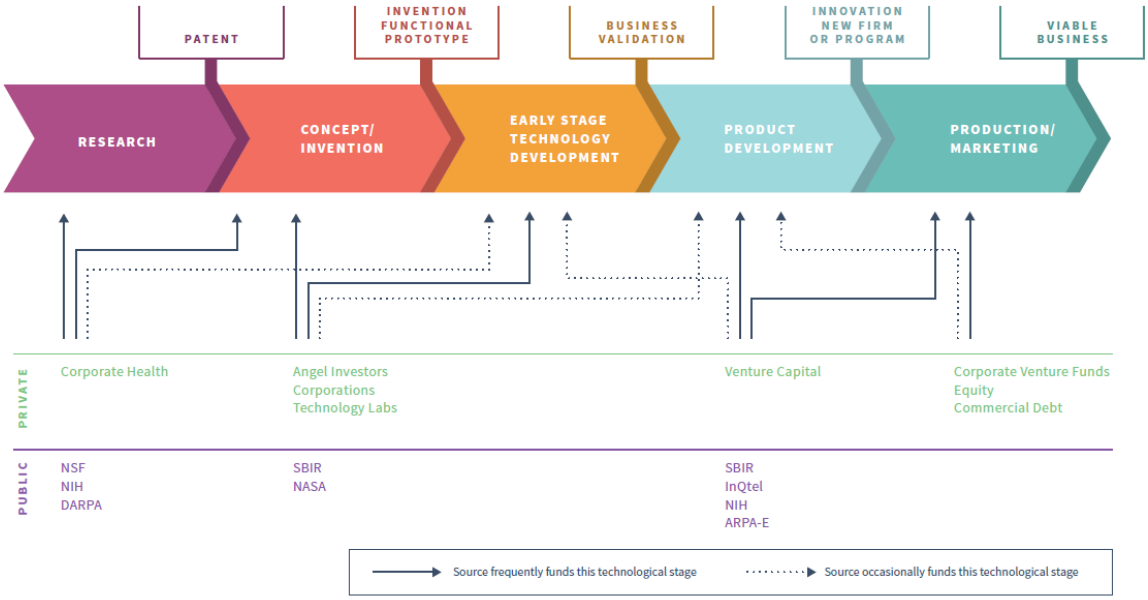
[40] Block, F. L. and Keller, M. R. (eds.) (2011) *State of innovation: the U.S. government's role in technology development*. Boulder, CO: Paradigm Publishers.
[41] Mooney, C. (2017) 'Trump wants to dismantle this energy innovation program. Scientists just found out that it works. *The Washington Post.* Article. Available at: https://www.washingtonpost.com/news/energy-environment/wp/2017/06/13/trump-wants-to-cut-this-energy-innovation-program-scientists-just-found-that-its-working/?utm_term=.6142ef9bf16a.
[42] Mazzucato, M. (2013) *The Entrepreneurial State*.
[43] Edler, J. & Georghiou, L. (2007) 'Public Procurement and Innovation: Resurrecting the Demand Side', Research Policy, 36(7), 949–63.
[44] Perez, C. (2013) "Financial bubbles, crises and the role of government in unleashing golden ages" in Pyka, A. and Burghof, H-P. (eds.) *Innovation and Finance.* Routledge: London.

Figure 2. Mission-oriented Finance along entire innovation chain

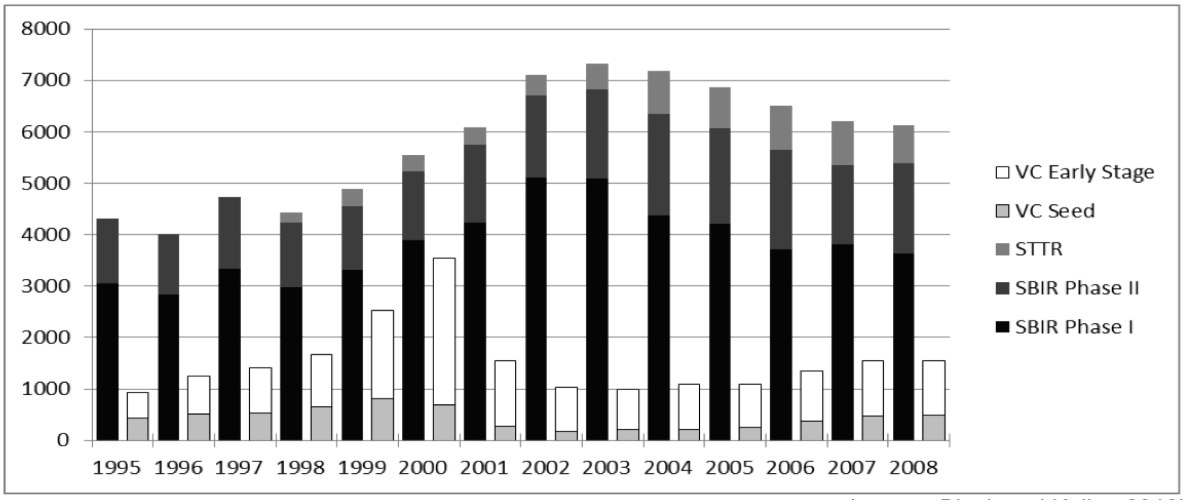


Source: Author's insertion of public funding agencies into original figure from Auerswald/Branscomb (2003).[45]

Figure 2 indicates some of the key public agencies in the US innovation landscape, including the National Institutes of Health (NIH), NASA, the Defense Advanced Research Projects Agency (DARPA), the sister organisation in the department of energy (ARPA-E), the Small Business Innovation Research Programme (SBIR), and the National Science Foundation (NSF), which have been active across the entire innovation chain. Such organisations have been 'mission driven' in that they have directed their actions based on the need to solve big problems, and in the process actively created new technological landscapes, rather than just fix existing ones.[46] Downstream investments included the use of procurement policy to help create markets for small companies, through the public Small Business Innovation Research (SBIR) scheme, which historically has provided more early stage, high-risk finance to small and medium sized companies than private venture capital has,[47] as **Figure 4** shows. And guaranteed government loans are regularly used to pump prime companies, such as the $465 million guaranteed government (DoE) loan received by Tesla to produce the 'Tesla S' car.[48]

[45] Auerswald , P. E. and Branscomb, L. M. (2003) 'Valleys of Death and Darwinian Seas: Financing the Invention of Innovation Transition in the United States'. Journal of Technology Transfer 28, nos. 3–4: 227–39.
[46] Foray, D., Mowery, D. and Nelson, R. R. (2012) "Public R&D and Social Challenges: What Lessons from Mission R&D Programs?".
[47] Block, F. L. and Keller, M. R. (eds.) (2011) *State of innovation: the U.S. government's role in technology development*.
[48] US Department of Energy Loan Programs Office, 'Tesla' (2017) Webpage. Available at: https://energy.gov/lpo/tesla.

Figure 3. Number of SBIR and STTR grants compared to private venture capital.



Source: Keller and Block (2012).

While it is a common perception that it is private venture capital that fund start-ups, evidence shows that most high-growth innovative companies receive their early stage high-risk finance from public sources, such as Yozma in Israel,[49] venture funds in public banks,[50] the SBIR se funds in the US,[51] and the Small Business Research Initiative in the UK.[52] While private venture capital is exit-driven, seeking returns within three to five years, these forms of public finance have been less risk-averse and more patient—thus better suited for the needs of innovation. This lesson does not seem to have been learned in various parts of the developed and developing world, where leaders continue to think that attracting venture capital (mainly through tax schemes, such as reductions in capital gains) will foster innovation. If we look to history we can see that venture capital entered industries like biotechnology in the late 1980s, while the high-risk capital intensive investments had been done by the US government in the 1950s and 1960s.[53]

In all these cases, government intervention was not driven by market failure. Instead, it deliberately targeted industries with public venture capital assistance. Similarly, in today's renewable energy sector, entrepreneurs like Elon Musk have received guaranteed loans from

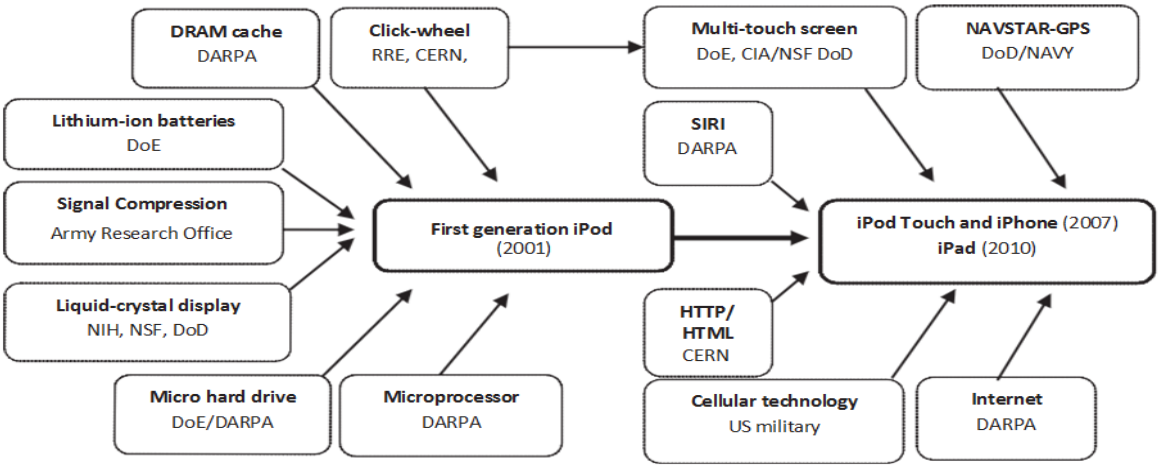
[49] Breznitz, D., and Ornston, D. (2013) "The revolutionary power of peripheral agencies";
[50] Mazzucato, M. and Penna, C. (2016b) "Beyond market failures: the market creating and shaping roles of state investment banks", Journal of Economic Policy Reform, 19(4): 305-326.
[51] Block, F. L. and Keller, M. R. (eds.) (2011) *State of innovation: the U.S. government's role in technology development*.
[52] Connell, D. (2014) 'Creating markets for things that don't exist: The Truth About UK Government R&D and How the Success of SBRI Points the Way to a New Innovation Policy to Help Bridge the Valley of Death and Rebalance the UK Economy'. Centre for Business Research, University of Cambridge. Available at: http://www.cc2-live.co.uk/davidconnell/docs/c%20dc-pub.pdf.
[53] Vallas, S. P., Kleinman, D. L. and Biscotti, D. (2011) "Political Structures and the Making of U.S. Biotechnologynology." In: Block, D and Keller, M. R. (eds,) State of Innovation: The U.S. Government's Role in Technology Development. Boulder CO: Paradigm.

the US Department of Energy, with the LA Times estimating that his three companies (Tesla, Space X and Solar City) have together received around $5 billion in public support.[54]

Decentralised network of mission-oriented agencies

Crucial to this public funding was the nature of the organisations themselves, what Block and Keller have called a *developmental network state*.[55] Better understanding of the distribution of public agencies, their positioning across the innovation chain, and the balance between directive and bottom-up interactions is a key area for future study.

Figure 4. Publicly funded technology in 'smart' phones



Source: Mazzucato (2013a), p.109, Fig. 13.

In the case of IT, as **Figure 4** illustrates, the technologies that have made Apple's i-products (iPhone, iPad, etc) 'smart' were initially funded by different public-sector institutions: the Internet by the Defense Activated Research Projects Agency (DARPA); global positioning system (GPS) by the US Navy; touchscreen display by the Central Intelligence Agency (CIA); and the voice-activated personal assistant Siri by DARPA.[56]

Key for our purposes is the fact most of the agencies developing the technologies were mission driven: they did not see their job as fixing markets but as actively creating them. Mission statements can help

[54] Hirsch, J. (2015) 'Elon Musk's growing empire is fueled by $4.9 billion in government subsidies'. *Los Angeles Times*. Available at: http://www.latimes.com/business/la-fi-hy-musk-subsidies-20150531-story.html.
[55] Block, F. L. and Keller, M. R. (eds.) (2011) State of innovation: the U.S. government's role in technology development.
[56] Mazzucato, M. (2013) The Entrepreneurial State.

direct public funds in ways that are more targeted than, say, simply helping all SMEs. Examples of mission statements include:

- **NASA**: to *"[d]rive advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth*." (NASA 2014 Strategic Plan).
- **DARPA:** "*Creating breakthrough technologies for national security is the mission of the Defense Advanced Research Projects Agency"*.
- **NIH**: to *"seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability"*.

Mission-oriented agencies are potentially better able to attract top talent as it is an 'honour' to work for them. By actively creating new areas of growth they are also potentially able to 'crowd in' business investment by increasing business expectations about where future growth opportunities might lie.[57]

Risk taking across the business cycle

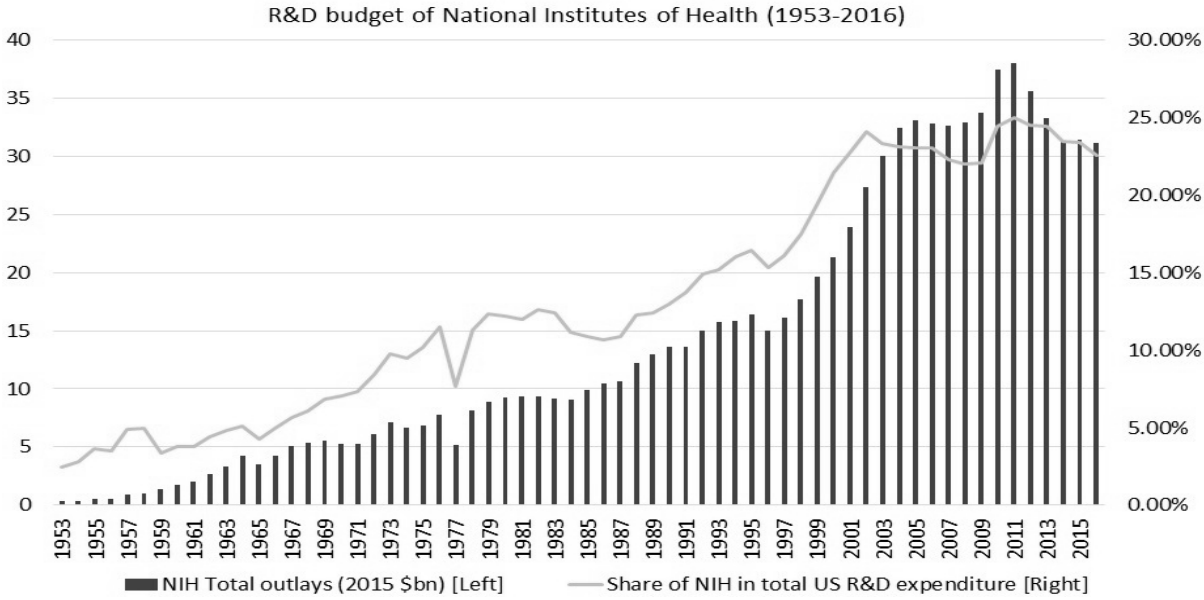
Market failure theory foresees the need to also fix 'coordination failures' such as pro-cyclical spending in the business sector. Indeed, much of Keynesian economics primarily considers the role of the state as essential in recessions (for its counter-cyclical role to prevent depressions), ignoring the fact that public financing of innovation has been just as important in boom periods. Evidence shows that mission-oriented agencies have been critical across the business cycle, not only to stimulate investment during recessions. The National Institutes of Health (NIH) have spent billions on health R&D, stimulating what later became the biotechnology revolution in both periods of boom and bust.

From 1936 to 2016, cumulative R&D expenditure by NIH has amounted to more than $900 billion (in 2015 dollars), and since 2004 has exceeded $30 billion per year (**Figure 5**). Perhaps unsurprisingly, research shows that around 75 percent of the most innovative drugs on the market today (the so-called 'new molecular' entities with priority rating) owe much of their funding to the NIH (Angell, 2004). Moreover, the share of R&D expenditure taken by NIH in total US federal outlays in R&D has increased year on year over the past 50 years. This suggests that the surge in absolute NIH-related R&D expenditure cannot simply be conceived as resulting from a generalised and proportional increase in total R&D expenditure by the government during downturns, or to simply level the playing

[57] Mazzucato, M. and Penna, C. C. R. (eds.) (2015a) Mission-Oriented Finance for Innovation: New Ideas for Investment-Led Growth. London: Policy Network/Rowman & Littlefield.

field. Instead, it appears as a deliberate and targeted choice on where to direct public R&D funding.

Figure 5. R&D budget of National Institutes of Health (1953-2016, in 2015 dollars).



Source: National Institutes of Health Office of Budget

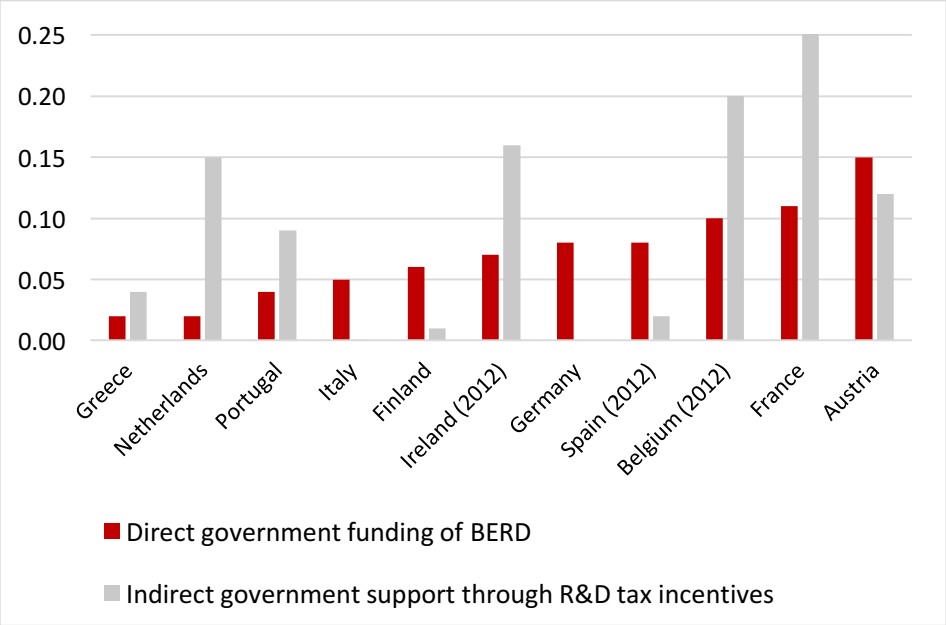
Mission-oriented financing as a direct form of investment

Mission-oriented investments are 'direct'. Tax incentives are 'indirect'. Direct investments that create new technological and industrial landscapes tend to crowd-in private investment more than indirect tax incentives. A typical and straightforward way of assessing the government support for innovation is to look at its contribution towards financing R&D activities broken down between direct and indirect mechanisms. As **Figure 6** shows, countries in the Eurozone present different patterns in this regard for financing Business Expenditure on R&D (BERD).

Relative to their GDP, the governments of Greece and Portugal spend between half and one third in direct funding of BERD compared to Austria, France and Germany. At the same time, Portugal and Greece dedicate a larger amount of resources to tax incentives for business R&D, such as allowances and credits, or in other forms of advantageous tax treatment of business R&D expenditure. However, in contexts where technological opportunities are lacking in the first place, due for instance to the lack of systemic and mission-oriented industrial and innovation policies, those incentives might be well used to avoid taxation and increase profits, without additional investment in R&D. It is well documented – for instance in Canadian

and Dutch studies[58 59]– that such indirect measures of R&D financing often do not make things happen that would not have happened anyway. Indeed, countries with higher indirect mechanisms (relative to direct) tend to have lower business spending on R&D (BERD).

Figure 6: Direct government funding of BERD and indirect government support for BERD as a percentage of GDP (2013)



Source: Authors' elaboration on OECD data
Notes: Indirect figures unavailable for Germany and Italy.

Another example of an indirect innovation policy that does not create additionality is that of the so-called 'patent box', introduced in the UK in 2013 and in Italy in 2015, following the examples of the Netherlands, Belgium and Spain. The patent box gives a tax relief on profits arising from registering a patent, which is itself a monopoly reward that seeks to defend the appropriability gain of the innovator from potential competitors. There is no reason to give an additional tax relief on that monopolistic rent: the patent entitlement is already the reward. The patent box is simply a second, additional compensation given to an activity that has already happened.[60] It would be much more effective to target spending on initiatives that encourage new waves of innovation, rather than the profits that are produced from past innovations.

[58] Dagenais, M, Mohnen, P. and Therrien, P., (1997) Do Canadian Firms Respond to Fiscal Incentives to Research and Development?. CIRANO, Scientific Series, 97s-34, October 1997, GREQAM document de travail 97B05.
[59] Lokshin, B. and Mohnen, P. (2013) Do R&D tax incentives lead to higher wages for R&D workers? Evidence from the Netherlands, *Research Policy*, Vol 42, Issue 3, pp823-830 http://dx.doi.org/10.1016/j.respol.2012.12.004.
[60] Griffith, R., Miller, H., and O'Connell, M. (2010) Corporate Taxes and Intellectual Property: Simulating the Effect of Patent Boxes, IFS Briefing Note 112, Institute for Fiscal Studies.

If governments want to implement innovation policies that generate real additionality, this suggests that rather than enhance the profitability of existing innovations, they should act as an investor of first resort in new ones, absorbing the high degree of uncertainty during early stages of innovation and possibly welcoming failures when they happens.

There are nonetheless positive examples in this respect. In the case of Germany, which ranks among the highest countries in the EU in every single innovation statistic, its success in recent decades can be ascribed to the combination of a directional "High-Tech" industrial strategy[61] and targeted mission-oriented programmes, such as the *Energiewende* for energy transition.[62] These policies are directly financed by the government, either through its federal budget – state aid directed to environmental protection and energy saving has increased by almost €25 billion between 2013 and 2014, the great bulk of it through grants[63] – or through the KfW, Germany's public investment bank, whose investments in energy efficiency projects in 2015 alone amounted to almost €15 billion.[64] On the contrary, industrial policy programmes which remain reliant on R&D tax credits and other indirect incentives will most likely not reinvigorate the "spontaneous urge to action rather than inaction", namely the endogenous "animal spirits" of the private sector to innovate.

Patient finance: the importance of public finance

It is precisely due to the short-term nature of private finance that the role of public finance is so important in nurturing the parts of the innovation chain subject to long lead times and high uncertainty. While in some countries this has occurred through public agencies, such as DARPA and NIH, in others, patient finance has been provided through publicly-owned development banks, otherwise known as state investment banks.

State investment banks (SIBs) have their historical roots in the monetary agreements of Bretton Woods and the reconstruction plans for Europe following the Second World War. The idea was to create an institution that promoted financial stability through a permanent flow of finance to fund the reconstruction plan and unleash agricultural production potential, thus preventing the deleterious effects that speculative private finance could have on post-war

[61] BMBF (2014) "The new High-Tech Strategy: Innovations for Germany". Bundesministerium für Bildung und Forschung / Federal Ministry of Education and Research (BMBF).
[62] BWMi (2015) "Making a success of the energy transition". Bundesministeriums für Wirtschaft und Energie / Federal Ministry for Economic Affairs and Energy (BWMi).
[63] European Commission (2016) "State Aid Scoreboard 2016". Available at: European Commission, scoreboard,index.
[64] KfW (2015) "2015 Financial Report". Kreditanstalt für Wiederaufbau, Frankfurt am Main, Germany. Available at: https://www.kfw.de/PDF/Download-Center/Finanzpublikationen/PDF-Dokumente-Berichte-etc /3_Finanzberichte/KfW-Finanzbericht-2015-E.pdf.

economic recovery.[65] Following this rationale, the International Bank for Reconstruction and Development (IBRD) was created, providing its first loan to France in 1947.[66] Other national development banks soon followed, such as KfW in Germany, with the aim of channelling international and national funds to the promotion of long-term growth, infrastructure and modern industry. While in industrialised countries these institutions focused on niche areas (such as aiding specific sectors), in developing countries SIBs such as the Brazilian BNDES initially promoted a catching-up agenda, with heavy investments in infrastructure.[67]

In subsequent decades, SIBs diversified their operations and focus. In the mid-1950s, KfW assumed the responsibility to provide finance for environmental protection and small and medium-sized enterprises (SMEs), roles that were intensified in the 1970s when it also began to target energy efficiency and innovation.[68] Other development banks followed suit. BNDES, for instance, created new credit lines for SMEs in the 1980s, and in the following decade began to experiment with financing programmes targeted at high-tech firms and innovation development.[69] By the 2000s, China Development Bank (CDB) was one of the most active SIBs, investing in regional economic development and industrial catching-up, supporting and nurturing new ventures and innovation development, and, later in the decade, targeting finance to projects aimed at 'green growth'.[70] After the outbreak of the global financial crisis in 2007, SIBs across the world significantly promoted counter-cyclical credit, increasing their loan portfolio by 36 percent on average between 2007 and 2009, with some increasing their loans by more than 100 percent.[71]

While the traditional functions of state investment banks were in infrastructure investment and counter-cyclical lending during recession when private banks restrained credit (thus playing a classic Keynesian role), they have, over time, become more active as key players in the innovation system. They have provided the patient capital for innovative firms, and also focused on modern societal challenges with technological 'missions'. For example, SIBs have notably filled the vacuum left behind by private commercial banks since the financial crisis, more than trebling their investments in

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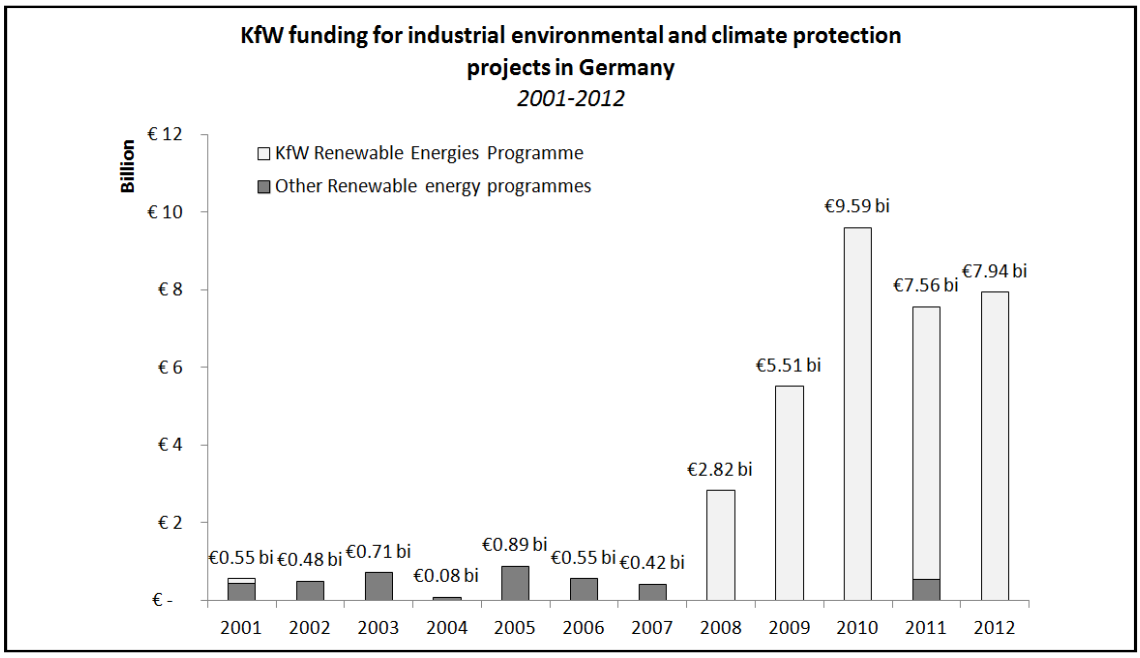
[65] World Bank (2015) History. Available at: http://go.worldbank.org/65Y36GNQB0. Accessed 15 December 2015.
[66] M.Schröder *et al*., *op. cit*.
[67] Torres Filho, E. T. and Costa, F. N. D. (2012) 'BNDES E O Financiamento Do Desenvolvimento', Economia e Sociedade, vol. 21, pp. 975–1009.
[68] KfW, 'Annual Report 2008', Frankfurt am Main (2009) KfW Group.
[69] Branco, C.E. (1994) 'Apoio às Pequenas e Médias Empresas de Base Tecnológica: A Experiência do Contec', Revista do BNDES, Vol. 1, pp. 129–142; F.L.D. SoUS (ed.) (2012) 'Bndes 60 Anos: Perspectivas Setoriais', Rio de Janeiro: BNDES.
[70] Sanderson, H. and Forsythe, M. (2013) 'China's Superbank: Debt, Oil and Influence – How China Development Bank is Rewriting the Rules of Finance', Singapore: John Wiley & Sons.
[71] Luna-Martinez, J. and L.Vicente, L. (2012) 'Global Survey of Development Banks', World Bank Policy Research Working Paper.

clean energy projects between 2007 and 2012.[72] [73] A recent report by Bloomberg New Energy Finance finds that in 2013 state investment banks were the largest funders of the deployment and diffusion phase of renewable energy, outpacing investment from the private sector.[74] The four most active banks are (in order): the Chinese Development Bank, the German KfW, the European Investment Bank (EIB), and the Brazilian BNDES. Examples of 'mission-oriented' investments include: the European Investment Bank's €14.7 billion commitment to sustainable city projects in Europe,[75] the efforts of KfW to support Germany's *Energiewende* policies through the greening and modernisation of German industries and infrastructures, China Development Bank's investments in renewable energies, and the technology fund put in place by BNDES to channel resources toward selected technologies in Brazil (FUNTEC).[76] **Figure 7** below, for example, illustrates the way in which KfW has not only played a classical Keynesian counter-cyclical role, but also directed that funding towards 'climate financing'.

Figure 7: KfW: Financing the Green Mission



[72] Mazzucato, M. and Penna, C. (2016b) "Beyond market failures: the market creating and shaping roles of state investment banks", *Journal of Economic Policy Reform*, 19(4): 305-326.
[73] L.S.Fried, S. Shukla and S. Sawyer (eds.) (2012) 'Global Wind Report: Annual Market Update 2011', Global Wind Energy Council, March 2012.
[74] Louw, A. (2012) 'Development banks: less for green in 2013?' Renewables Research note, 2012, Bloomberg New Energy Finance.
[75] Griffith-Jones and J.Tyson, (2012) 'The European Investment Bank and Its Role in Regional Development and Integration', in: The Transformations of the International Financial System, M.A.Cintra and K.D.R.Gomes (eds.), Brasília: IPEA.
[76] BNDES 2012. 'Apoio À Inovação' (2012) Rio de Janeiro: BNDES.

Risks and rewards

Considering these roles more explicitly allows us to reflect on the degree to which the division of labour in risk-taking is matched or not by a division of rewards, which one would expect if there is a *risk-return* relationship. It also helps us to better understand whether the eco-system is creating the right incentives. Is it the case that because some actors are putting in a lot, other actors have been given fewer incentives to do their share?

Innovation is highly uncertain: for every success (eg the Internet) there are many failures. High failure rates are just as common upstream (in R&D projects) as downstream in public financing of firms. A better understanding of how portfolios are managed in mission-oriented agencies is therefore important —such as in Yozma in Israel, Sitra in Finland, or SBIR in the US. This requires a lead investor understanding of public funds that goes beyond the need to correct for asymmetric information. It is not a matter of lacking information, but rather the willingness to engage in big thinking and its underlying uncertainty.

Having a vision about the direction in which to drive an economy requires direct and indirect investment in particular areas, not just creating the horizontal (framework) conditions for change. Crucial choices must be made, the fruits of which will create some winners, but also many losers. For example, the US Department of Energy recently provided guaranteed loans to two green-tech companies: Solyndra ($500 million) and Tesla Motors ($465 million). While the latter is often glorified as a success story, the former failed miserably and became the latest example in the media of a government being inefficient and unable to pick winners.[77] However, any venture capitalist will admit that for every winning investment (such as Tesla) there are many losses (such as Solyndra).

In making its downstream investments, therefore, governments can learn from portfolio strategies of venture capitalists, structuring investments across a risk space so that lower risk investments can help to cover the higher risk ones. In other words, if the public sector is expected to compensate for the lack of private venture capital (VC) money going to early-stage innovation, it should at least be able to benefit from the wins, as private VC does. Otherwise, the funding for such investments cannot be secured. As argued in Mazzucato and Wray, even if money could be secured for public investments endogenously (through money creation), it is desirable to allow the state to reap some of the rewards from its investments for a number of other reasons.[78] Matching this type of spending with the corresponding return would provide a measure of efficiency, holding

[77] Wood, R. (2012) 'Fallen Solyndra Won Bankruptcy Battle but Faces Tax War'. Forbes, 11 June. Available at: http://www.forbes.com/sites/robertwood/2012/11/06/fallen-solyndra-won-bankruptcy-battle-butfaces-tax-war/.

[78] Mazzucato, M. and Wray, L. R. (2015) "Financing the Capital Development of the Economy: A Keynes-Schumpeter-Minsky Synthesis", Working Paper, n. 837, Levy Economics Institute. Available at: http://www.levyinstitute.org/pubs/wp_837.pdf.

policymakers accountable; government net spending has limits dictated by the real resource capacity of the economy; and voters will be more willing to accept the (inevitable) failures if they see that those are compensated by important successes.

The public sector can use a number of return-generating mechanisms for its investments, including retaining equity or royalties, retaining a golden share of the IPR, using income-contingent loans, or capping the prices (which the tax payer pays) of those products that emanate, as drugs do, from public funds.[79] Before exploring the details of each mechanism, however, it is crucial for the policy framework to allow the question to be asked. In a market-shaping framework, does government have the right to retain equity more than in a market failure framework? Are taxes currently bringing back enough return to government budgets to fund high-risk investments that will probably fail?

Learning the right lessons from The Entrepreneurial State

> *"Public values are those providing normative consensus about (1) the rights, benefits, and prerogatives to which citizens should (and should not) be entitled; (2) the obligations of citizens to society, the state, and one another; (3) and the principles on which governments and policies should be based."*
>
> ***Barry Bozeman,*** *2007*[80]

Weiss places caution on the role of US public agencies in fostering innovation.[81] She highlights the strong military and security interests that have shaped US innovation policy, and the way that corporate interests have taken advantage of these.

It is right to be cautious. And it is precisely a wide debate about what it means to have mission-oriented thinking that can allow active public policy in innovation to be re-directed towards societal needs (and the wicked problems that connect health, sustainability, nutrition, education, and poverty) and not only military and security needs. By creating a more symbiotic relationship between the public and private sectors—focused on targets of 'additionality'— the possibility of particular sectors to capture innovation policy is reduced, as is the possibility that particular companies lobby for policies (including tax policies) which increase profits but do not help the generation of public value.

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[79] Mazzucato, M. (2013) The Entrepreneurial State, Anthem.

[80] Bozeman, B. (2007) Public values and public interest: counterbalancing economic individualism. Georgetown University Press

[81] Weiss, L. (2014) America Inc.?: Innovation and enterprise in the national security state. Ithaca; London: Cornell University Press.

Understanding how the definition of missions can be opened up to a wider group of stakeholders, including movements in civil society, is a key area of interest. Indeed, it was to a large extent the green movement in Germany (including but not restricted to the Green Party) that led to a slow cumulative interest in society about tackling green missions, which was subsequently represented in the *Energiewende* agenda.

Understanding more democratic processes through which missions are defined and targeted is tied to rethinking the notion of public value. Indeed, part of building a market shaping and creating framework that can guide mission-oriented thinking beyond the market failure framework involves rethinking *public value* beyond the notion of the "public good". Too often the public good concept has been used to limit and constrain the activities of public actors, creating a static distinction between those activities for business and those for policy. This means that ambitious policies—daring to reimagine the market rather than just fixing the public good problem-- have then been accused of 'crowding out' private activity, whether the accused are innovation agencies, public banks or the BBC.[82]

But similarly, achieving public value cannot be the work only of the public sector, hence opening up this process to include a wider set of stakeholders – involved in the definition of missions as well as the serendipitous process of how to achieve them – will be an exciting new area of analysis linked to 21st century innovation policy targeting grand challenges.

[82] Mazzucato, M. and O'Donovan, C. (2016) "The BBC as market shaper and creator" in Rethinking the BBC: Public media in the 21st Century, Seth-Smith, N., *et. al*. (eds.), Commonwealth Publishing. Available at: http://commonwealth-publishing.com/shop/rethinking-the-bbc-public-media-in-the-21st-century/.

Implementing mission-oriented policies

The historical examples and future potential of mission-oriented policy approaches have led to growing interest from around the world. But questions remain about how to apply the lessons of history to the challenges of today.

When policy-makers have acted in this way in the past, they have had to work outside established policy frameworks. What is needed is a policy framework they can work within: a new framework that can be used to justify, guide and evaluate mission-oriented innovation policies.

The challenge is to develop this new framework, along with the analytical tools, related policy apparatus, and new organisational capabilities to enable policy-makers to apply it in practice – in relation to different types of challenges and in different spatial or other contexts. To conclude this scoping paper, some general principles are listed below.

Linking innovation policy to the systemic characteristics of innovation

Innovation policy must build on the key characteristics of how innovation comes about: it is uncertain, cumulative and collective.[83]

- **Uncertainty** means that agents concerned with innovation cannot calculate in advance the odds of success or failure – that is, results are unknown – and therefore in order to succeed will have also to accept occasional failures and detours from planned routes.
- **Cumulative** means that agents need to be patient and act strategically to accumulate competences and capabilities (learn) with a view to the long term.
- **Collective** means that all agents need to work together and thus bear certain degrees of risk; they are therefore entitled to also share the rewards.

Policies based on a mission-oriented perspective are systemic, employing but going beyond science-push instruments and horizontal instruments. Mission-oriented policies employ the array of financial

[83] Lazonick, W. and Mazzucato, M. (2013) 'The risk-reward nexus in the innovation-inequality relationship: who takes the risks? Who gets the rewards?', Industrial and Corporate Change, 22(4), pp. 1093-1128.

and non-financial instruments to promote the accomplishment of a mission across many different sectors, setting concrete directions for the economy, and deploying the necessary network of relevant public and private agents.

A *broad perspective* on the national system of innovation identifies four subsystems: (i) public policy and public funding; (ii) research and education; (ii) production and innovation; and (iv) private finance and private funding. While all subsystems are theoretically of strategic importance, the subsystem of public policy and funding has traditionally led the process of socio-economic development and technical change.

In order to stimulate the innovation process by shaping and creating technologies, sectors and markets, new relationships must be developed and more trust must be created. The state must galvanise the interests of relevant actors and organise itself so that it has the 'intelligence' to think big and formulate bold policies that also create a sense of ownership amongst diverse public, private and academic stakeholders. It is also crucial to be able to implement the policies by coordinating the efforts of this network of stakeholders through the state's convening power, brokering of trust relationships, and the use of targeted policy instruments.

To fulfil a mission, a country requires an entrepreneurial state. This concept encapsulates the risk-taking role adopted by the state in the few countries that have managed to achieve innovation-led growth. It is through mission-oriented policy initiatives and investments across the entire innovation process – from basic research to early-stage seed financing of companies – that the state is able to have a greater impact on economic development.

Different types of capacity building

Different types of capacity building are central to mission-oriented policies:

- **Scientific-technological capacity:** an appropriate scientific and technological knowledge base in the subsystem of education and research;
- **Demand capacity:** latent or effective (public or private) market demand, in terms of both purchasing power and need;
- **Productive capacity:** an appropriate business base (for example, existing firms or entrepreneurs willing to take risks to establish an innovative firm) in the subsystem of production and innovation;
- **State capacity:** appropriate knowledge inside the public organisations formulating and executing the policies about the problem and solution being targeted and/or knowledge about who-knows-what-and-how;

- **Policy capacity**: appropriate supply-side and demand-side policy instruments (strategically deployed), supported by complementary policies;
- **Foresight capacity:** a fine-tuned diagnosis of the problem and solution, including an analysis of the current situation and future prospects for targeted technologies and sectors, formulated in terms of a well-defined mission and vision.

Successful mission-oriented policy experiments require all six factors in place. They require a more dynamic framing of key questions: less about picking or not picking, and more about the institutional and organisational capacity of forming broadly defined directions, through strategic deliberation. Less about static cost-benefit metrics which so often result in accusations of 'crowding out' and more about dynamic assessment criteria that can nurture and evaluate market shaping processes and capture the spill-overs that are created across sectors.

The way forward: a practical approach to implementing mission-oriented innovation policies

We opened this paper with the observation that governments are increasingly seeking economic growth that is smart (innovation-led), inclusive and sustainable. We need to see this in the context of grand social challenges such as tackling climate change, improving public health and wellbeing, and adjusting to demographic changes.

Mission-oriented innovation policy has a major part to play in delivering better quality growth while addressing grand challenges, but the changes in mind-set, theoretical frameworks, institutional capacities and policies required are by no means trivial. So what is the practical way forward?

In this respect, four key questions—denoted by the acronym R-O-A-R—can guide the process of developing the new framework to justify, guide and evaluate mission-oriented innovation policies:[84]

- **Routes and directions**: how to use policy to actively set a direction of change; how to foster more dynamic (bottom-up) debates about possible directions to ensure enduring democratic legitimacy; and how to choose and define particular missions concretely, but with sufficient breadth to motivate action across different sectors of the economy.
- **Organisations**: how to build decentralised networks of explorative public organisations that can learn-by-doing and welcome trial and error, with the confidence and capability to

[84] These questions are developed in: Mazzucato, M. (2016a) "From Market Fixing to Market-Creating: A new framework for innovation policy", Special Issue of *Industry and Innovation:* "Innovation Policy – can it make a difference?", 23 (2).

lead and form dynamic partnerships with private and third sector partners; how to manage and evaluate progress, learning and adaptation; and how to use a portfolio approach to balance inevitable failure with success.

- **Assessment**: how to evaluate the dynamic impact of public sector market-creating investments, going beyond the static ideas embodied in cost/benefit analysis and ideas of 'crowding in' and 'crowding out' based on a richer conception of public value creation'; how to develop new indicators and assessment tools to aid decision-making.
- **Risks and rewards**: how to form new deals between public and private sectors so that rewards as well as risks are shared.

These questions provide a starting point for the new categories of thought that are needed, with many more questions following in relation to application in particular contexts.

Figure 7 below can be used to reflect on the practical steps that might be useful for mission-oriented organisations.

Figure 7: Practical steps for mission-oriented organisations

Mission selection	How to select missions that have enduring and democratic legitimacy
Co-production	How to engage public, private and third sector actors in mission selection, implementation, learning and evaluation processes
Mission definition	How to define missions concretely but with sufficient breath to motivate action across multiple sectors of the economy, enabling new types of interactions between public, private and third sectors, and over different time horizons
Dynamic capacities	How to develop new competencies and capabilities for dynamic change: ability to envision new futures and to accommodate risk-taking, experimentation and underlying uncertainty of the discovery process
Decision tools	How to develop new indicators and assessment tools to aid decision-making and evaluate impact, beyond the static cost/benefit framework
Managing failure	How to manage inevitable failure as well as success by taking a portfolio approach
Sharing rewards	How to ensure rewards as well as risks are shared so that the growth generated is inclusive as well as smart

Mission-oriented innovation policy is far from being a step into the unknown. As set out in this paper, there is substantial theory, evidence, case studies and experience accumulated over many decades of successful practice. It is also important to understand the challenges associated with gathering the necessary political commitment and public legitimacy behind such ambitious policies.

To reap the substantial benefits from this approach, what is needed is to abandon the ideology that often informs, and misinforms, the role that the state can play in the economy. Public, private and third sector actors can work together in new ways to co-create and shape the

markets of the future. We can learn from practical policy experiences to foster a more coherent and cohesive framework across sectors, institutions and nations. Only in this way can investment led growth help address not only the growth problem but help solve the wicked 21st century challenges ahead.

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