

# Mission-oriented innovation policies: challenges and opportunities

Mariana Mazzucato\*

UCL Institute for Innovation and Public Purpose, University College London, Gower Street, London WC1E 6BT, UK. e-mail: m.mazzucato@ucl.ac.uk

\*Main author for correspondence.

## Abstract

This article focuses on the broader lessons from mission-oriented programs for innovation policy—and indeed policies aimed at investment-led growth. While much has been written about case studies on missions, this has not resulted in an alternative policy making toolkit. Missions—in the least—require those tools to be just as much about market cocreating and market shaping, as they are about market fixing. The article reviews the characteristics of mission-oriented programs, looks at key features of those programs that can provide lessons, and discusses how to choose and implement mission-oriented policies, with an example.

**JEL classification:** B52, O25, O33, O38

## 1. Introduction

Innovation has not only a rate but also a direction: 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 well-being concerns, and 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, as well as redistributive tax policy. 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.

Turning these challenges into concrete problems that drive innovation across multiple sectors and actors have much to learn from “mission-oriented” policies that in the past has been aimed at achieving specific objectives, whether landing a man on the moon or battling climate change (Ergas, 1987; Mowery 2010; Mazzucato, 2014; Mazzucato 2017). Such policies require different actors (both public and private) and different sectors to innovate (going to the moon required innovation in aeronautics, robotics, textiles, and nutrition). At the same time, to be successful, they must enable bottom-up experimentation and learning so that the innovation process itself is nurtured through dynamic feedback loops and serendipity (Rodrik, 2004).

Examples of such direction-setting policies abound, including different technology policy initiatives in the United States (Mowery et al., 2010), France (Foray et al., 2009), the UK (Mowery et al., 2010), and Germany (Cantner and Pyka, 2001). Mission-oriented policies are not just about throwing funds at problems but doing so in specific ways. It is for this reason that it is useful to study how specific mission-oriented agencies and organizations have worked

whether in the military R&D programs or in areas like health (Sampat, 2012), agriculture (Wright, 2012), or energy (Anadon, 2012). In these examples, the relevant organizations made choices on what to fund, going against the more classic position that the point of policy making is simply to level the playing field. Indeed, these agencies, and the wider programs around them, “tilted” the playing field through missions aimed at a public objective, with other policies needing to be introduced to make it more profitable to move in that direction (e.g., the US land grant system or tax reliefs for green investments) (Mazzucato and Perez, 2015).

In this article, I focus on the broader lessons from mission-oriented programs for innovation policy—and indeed policies aimed at investment-led growth. While much has been written about case studies on missions (Mowery et al. 2010), this has not resulted in an alternative policy making toolkit. Missions—in the least—require those tools to be just as much about market cocreating and market shaping, as they are about market fixing (Mazzucato, 2016).

Section 2 reviews the characteristics of mission-oriented programs; Section 3 looks at key features of those programs that can provide lessons; Section 4 discusses how to choose and implement mission-oriented policies, with an example; and Section 5 concludes.

## 2. From technological feats to wicked problems

Mission-oriented policies can be defined as systemic public policies that draw on frontier knowledge to attain specific goals, or “big science deployed to meet big problems” (Ergas, 1987). While 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 challenges that are as much social as technological (Foray et al., 2012). The active role being taken by governments and transnational organizations to develop strategies for a greener economy can be seen through a mission-oriented lens—as can those being developed to create more wellbeing for an ageing population, and better jobs for modern youth (European Commission, 2011). 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, as discussed in the Introduction of this special issue (Kattel and Mazzucato, 2018), societal missions are much more complex because they are less clearly defined and indeed must be co-defined by many stakeholders (how to frame the challenge around inequality is more difficult than those around the space race) (Foray et al., 2012). One could add that these challenges also require big regulatory and behavioral changes at the societal/national systems level. Nelson’s work on *The Moon and the Ghetto* (Nelson, 2011) asked the demanding question of why innovation has resulted in such difficult feats as landing a man on the moon, and yet continues to be so terribly disorganized and technologically unsavvy in dealing with the more earthly problems of poverty, illiteracy, and the emergence of ghettos and slums. He argued that while politics was partly the culprit, the real problem was that a purely scientific and technological solution could not solve such problems. Even at the disciplinary level there is a greater need to combine understandings of sociology, politics, economics, and technology to solve these problems, as well as to make the conscious decision to point innovation toward them. This is exactly what a well-designed mission can achieve.

The so-called Maastricht Memorandum provides a detailed analysis of the differences between old and new mission-oriented projects (Table 1).

Although the memorandum specifically focuses on mission-oriented programs 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, and increasingly those in the nonprofit sector. They will in most cases also require changes in regulation and tax policies. And the diffusion of solutions to a broad base of users requires as much attention to demand-side policies as to supply side.

The six characteristics of contemporary missions identified in Table 1—diffusion of technologies, economic feasibility, shared sense of direction, decentralized 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

**Table 1.** Characteristics of old and new mission-oriented projects

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
Centralized control within a government administration	Decentralized 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 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: 51).

capabilities is key for the success of any mission-oriented policy. These can be described as follows (Mazzucato and Penna, 2016a):

- **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 use them as learning experiences. Furthermore, stakeholders should not be punished because of failures derived from good-faith efforts.
- **Missions should result in investment across different sectors and involve different types of actors.** To have highest impact, missions should embrace actors across an entire economy, not just in one sector and not just in the private or public realm.
- **Missions require joined up policy making,** 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 labor among 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 potential of the country's science and technology system to develop innovations.

### 3. Key lessons from mission-oriented policies

Mission-oriented policies can transform the policy makers' tool kit. The next section reviews ways in which mission thinking requires an alternative lens for policy making.

#### 3.1 From picking winners to picking the willing

Missions are about setting concrete directions, which of course must be picked, that is, chosen strategically. The choice is not whether to pick but *how*: picking directions is not the same thing as "picking winners" in the sense of picking individual firms or sectors. It is about deciding that a transformation must occur in society—and making it happen. The direction will require different missions, which provide a focusing device for the different actors and

sectors to collaborate to concretely achieve it. Thus missions require *picking the willing*: those organizations across the economy (in different sectors, including both the public and private sphere) that are “willing” to engage with a societally relevant mission.

Missions are a new way to frame “vertical policies.” Industrial and innovation policies require both horizontal and vertical policies working together systemically. Traditionally, industrial strategy has often focused on (vertical) sectoral interventions. Until the end of the 1970s, this consisted of various measures ranging from indicative planning to outright nationalization of entire industries (e.g., 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 negotiating specific provisions with the government (Buchanan, 2003), negatively influencing the industrial strategy with indirect measures (e.g., tax credits) that potentially waste public funds and create little if no additionality in terms of new investment. The patent box tax policies being adopted in many countries represents an example of these misconceived policies, since there is no reason to lower tax on monopoly profits, and it has shown to have little effect on additional research investment (Griffith et al., 2010).

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 well-being, mobility issues, etc.—governments have the opportunity to determine the direction of growth by making strategic investments throughout the innovation chain and creating the potential for greater spillovers across multiple sectors, including low-tech sectors (Foray et al., 2012).

Germany’s *Energiewende* is an interesting case of the use of 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. While the steel industry in many countries remains relatively low tech and subsidized, it was the *Energiewende* policy that placed pressure on steel to lower its material content. It did so through the use of a “reuse, recycle, and repurpose” strategy (BMUB, 2016). In this sense, mission-oriented policies should be focused on ways to provide sectors with transformation policies—less subsidies and more focused policies that reward investment and innovation that meet a need.

### 3.2 From fixing markets to actively co-shaping

Missions do not fix existing markets but create new markets. Indeed, this ambition toward transformation can be seen in the explicit remit of mission-oriented organizations. Examples below from three classic mission-oriented agencies exemplify the point: the organizations are not about fixing existing markets but creating new landscapes.

- **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.”

By breaking new ground, and bringing together different players, they are a better able to attract top talent, as it is an “honour” and interesting 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 (Mazzucato and Penna, 2015a).

This proactive approach, whereby the state leads and business follows, is different from the traditional approach where the state is at best a fixer of markets. The market fixing approach 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 (e.g., public goods like basic research, which require public sector spending on science), negative externalities (e.g., pollution, which require public sector taxation), and incomplete information

(where the public sector may provide incubators or loan guarantees).<sup>1</sup> 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 (Lundvall, 1992).

And yet missions exemplify a more proactive approach to policy than fixing suggests. It has required public organizations to be responsible for actively shaping and creating markets and systems, not just fixing them, and for creating wealth, not just redistributing it.

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, which actively cocreates new markets, requires continuous and dynamic monitoring and evaluation throughout the innovation policy process. The notion of public value becomes a more useful term than a public good, since missions may be transformative across the entire value chain and not be limited to narrow areas where positive and negative externalities exist.

### 3.3 From fearing failure to welcoming experimentation

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 to scrutinize 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 (Mazzucato, 2016).

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 (Ergas, 1987). The state must therefore be able to learn from past experiences in mission-oriented innovation policy.

*Systems* and ecosystems 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, and intermediary institutions) as well as horizontal links *within* organizations and institutions (Freeman, 1995). What, also should be emphasized, 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 (Mazzucato, 2016).

To stimulate the innovation process by shaping and creating technologies, sectors, and markets, missions require dynamic relationships to be developed which create trust between actors. It is essential in this process for the lead public organizations to galvanize the interests of relevant actors and organize itself so that it has the “intelligence” to think big and formulate bold policies that create a sense of ownership among 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.

Because innovation is extremely uncertain, the ability to experiment and explore is key for a successful entrepreneurial state (Hirschman, 1967; Rodrik, 2004; Mazzucato, 2013). Therefore, a crucial element in organizing the state for its entrepreneurial role is *absorptive capacity* or *institutional learning* (Cohen and Levinthal, 1990; Johnson, 1992). Governmental agencies learn in a process of investment, discovery, and experimentation that is part of mission-oriented initiatives. This requires, as discussed in the Introduction of this special issue, “dynamic capabilities” of the public sector.

Other authors have referred to processes of experimentation and learning process as “smart specialization” (Foray et al., 2009).<sup>2</sup> However, smart specialization 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 specialization 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 (2013) focus on the

1 Reviews of the impact of positive externalities and incomplete information on innovation financing are provided in Hall (2002) and Hall and Lerner (2010), and more recent evidence is reviewed in Kerr and Nanda (2015). The role for government in the face of negative externalities (climate change) is laid out in Jaffe et al. (2005).

2 See also Foray’s discussion of smart specialization as mission-oriented policy in this issue.

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. 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 United States were not so peripheral, as can be seen by DARPA's continued success in recent years. What seems to be more important for these organizations 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.

### 3.4 From a focus on quantity of finance to a focus on the quality

By focusing on the market making role, rather than the market fixing one of missions, it also becomes clearer why they have required public investments by mission-oriented institutions along the entire innovation chain, not only upstream basic research. Institutions like the National Science Foundation (NSF) have been critical to basic research (e.g., NSF), institutions like DARPA and Advanced Research Projects Agency-Energy (ARPA-E) to translational research and institutions like Small Business Innovation Research (SBIR) to long-term finance for companies. Block has called this distributed network of different state actors the *developmental network state* (Block and Keller, 2011). Better understanding of the distribution of public agencies, their positioning across the innovation chain, and the balance between directive and bottom-up interactions are a key area for future study.

From 1936 to 2016, cumulative R&D expenditure by National Institutes of Health (NIH) has amounted to more than \$900 billion (in 2015 dollars), and since 2004, it has exceeded \$30 billion per year. Perhaps unsurprisingly, research shows that around 75% 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, 2005). 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 generalized and proportional increase in total R&D expenditure by the government during downturns, or to simply level the playing field. Instead, it appears as a deliberate and targeted choice on where to direct public R&D funding.

Due to the short-term nature of private finance, the role of public institutions is often to provide longer lead times and the willingness to engage with high uncertainty. While in some countries this has occurred through public agencies, such as DARPA and NIH mentioned earlier, in others, patient finance has been provided through other institutions, including publicly owned development banks, otherwise known as state investment banks (SIBs) (Mazzucato and Semieniuk, 2017). 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 postwar economic recovery (World Bank, 2015).

While the traditional functions of SIBs were in infrastructure investment and countercyclical 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 clean energy projects between 2007 and 2012 (Fried et al., 2012; Mazzucato and Penna, 2016b). A report by Bloomberg New Energy Finance finds that in 2013, SIBs were the largest funders of the deployment and diffusion phase of renewable energy, outpacing investment from the private sector (Louw, 2012). Examples of "mission-oriented" investments include the European Investment Bank's €14.7 billion commitment to sustainable city projects in Europe (Griffith-Jones and Tyson, 2012), the efforts of KfW to support Germany's *Energiewende* policies through the greening and modernization of German industries and infrastructures, China Development Bank's investments in renewable energies, and the technology fund put in place by BNDES (2012) to channel resources toward selected technologies in Brazil (FUNTEC).

### 3.5 Engagement

Understanding how the definition of missions can be opened up to a wider group of stakeholders, including movements in civil society (as discussed by Leadbeater in this special issue), 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 (Mazzucato and O’Donovan, 2016).

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.

### 3.6 From de-risking to sharing both risks and rewards

Missions require a vision about the direction in which to drive an economy, focusing investment in particular areas, not just creating the horizontal (framework) conditions for change. Even if this is not about “picking winners” in the classical sense, but more about “picking the willing” (those organizations across the economy interested and willing to help achieve a mission), crucial choices must be made on which organizations to support, the fruits of which will create some winners, but also many losers. For example, as part of Obama’s drive to create green growth, the US Department of Energy 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 (Wood, 2012). However, any venture capitalist will admit that for every winning investment (such as Tesla) there are many losses (such as Solyndra).

And these types of investments are often those that private venture capitalists are not willing to make due to their exit driven model that seeks short-term returns (usually 3–5-year cycles). In many sectors, venture capital (VC) have entered after only after decades of public investments (e.g., NIH in biotech, or the role of SBIR in other areas, as discussed in Block and Keller, 2011). And some have argued that it is precisely this short-termism that has caused problems in sectors like biotechnology (Pisano, 2006; Lazonick and Tulum, 2011).

But there is also another side of the story. If the public funds do act as public forms of VC, then there is reason to argue that the rewards should be proportional to the risks actually taken. 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 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. It may be desirable to allow the state to reap some of the rewards from its investments for a number of other reasons (Mazzucato and Wray, 2015). Matching this type of spending with the corresponding return would provide a measure of efficiency, holding 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.

As discussed in Mazzucato (2013) and Laplane and Mazzucato (2018), 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 (Mazzucato, 2013).

### 3.7 In sum, a new approach to policy making

The principles above can be summarized along four big questions, which are summarized with the provocative acronym R-O-A-R. Policy must ROAR to lead with an ambitious challenge, nurture organizational capabilities, new

forms of assessment, and a better sharing of rewards so that innovation-driven growth can also result in inclusive growth (Mazzucato, 2016).

- **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? How to choose and define particular missions concretely, but with sufficient breadth to motivate action across different sectors and actors in an economy?
- **Organizations:** How to build decentralized networks of explorative public organisations that can learn-by-doing and welcome trial and error, with the confidence and capability to 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 structure new types of deals between public and private sectors so that rewards are shared as much as risks taken?

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.

#### 4. Choosing and implementing mission-oriented policies

Missions should be broad enough to engage the public and attract cross-sectoral investment and remain focused enough to involve industry and achieve measurable success. By setting the direction for a solution, missions do not specify how to achieve success. Rather, they stimulate the development of a range of different solutions to achieve the objective. As such, a mission can make a significant and concrete contribution to meeting an Sustainable Development Goals (SDG) or Societal Challenge. Figure 1 illustrates the movement from broad challenges to specific missions.



Figure 1. From challenges to missions image: RTD-A.1 based on Mazzucato (2018).



For example, SDG 14 “Conserve and sustainably use the oceans, seas and marine resources for sustainable development” could be broken down into various missions, for example “A plastic-free ocean.” This could stimulate research and innovation in means to clear plastic waste from oceans or in reducing use of plastics, innovation in new materials, research on health impacts from micro-plastics, behavioral research, and innovation to improve recycling or drive public engagement in cleaning up beaches. Each of these areas can be broken down into particular “projects.” This is further analyzed in the example section of this report, as well as other illustrative examples.

Missions must be chosen. Yet their success will depend on the bottom-up processes that nurture innovation while “getting there.” A culture of experimentation and risk-taking is a crucial element in the philosophy of missions. There must be incentives to “think outside the box” to come up with new solutions to address the mission objective. This requires a portfolio approach, based on different solutions, and a broad range of different interactions. The objective should be addressed by multiple actors, stimulating cross-discipline academic work, with a strong focus on the intersection between natural sciences, formal sciences, social sciences, and humanities; collaborations across different industries; and new forms of partnerships between the public sector, the private sector, and civil society organizations. Innovation itself is often characterized by feedback effects, trial and error, and serendipity (the search for one thing leads to the discovery of another)—picking missions that have different possibilities for solutions will enhance the innovation dynamic itself.

How should missions be picked? The following five criteria build on the issues raised above and are clearly set out in the European Commission report on Missions that will be framing the new Framework Programme (FP) Horizon program (Mazzucato, 2018):

(1) Bold, inspirational with wide societal relevance

Missions should engage the public. They should make clear that through ambitious, bold action at the European level, solutions will be developed that will have an impact on people’s daily lives. To do this, missions must outline exciting opportunities for bold innovation—while being connected to debates in society about what the key challenges are, like sustainability, inequality, health, climate change, and increasing the quality of the welfare state.

(2) A clear direction: targeted, measurable, and time-bound

Missions need to be very clearly framed. While enabling long-term investments, they need a specific target that can either be formulated in binary ways (as clearly as whether man has reached the moon and returned back safely) or quantified (as clearly as whether a certain percentage reduction in carbon emissions against a baseline has been reached across manufacturing). In addition, they will need a clear time frame within which actions should take place. This needs to be long enough to allow the process to grow, for actors to build relationships and interact, while at the same time being time-limited. Without specific targets and timing, it will not be possible to determine success (or failure) or measure progress toward success.

(3) Ambitious but realistic research and innovation actions

Mission objectives should be set in an ambitious manner (taking risks), centered on research and innovation activities across the entire innovation chain, including the feedback effects between basic and applied research. Ambitious objectives will ensure that researchers and innovators are challenged to deliver what would otherwise not be attempted (“additionality” in research). Yet, the objective should be framed to be on the one hand high-risk but also realistically feasible, at least in theory, within the given time period. Setting the technical objectives unrealistically high will result in a lack of buy-in, while setting the objective too low will not incentivise extra efforts—or provide inspiration.

(4) Cross-disciplinary, cross-sectoral, and cross-actor innovation

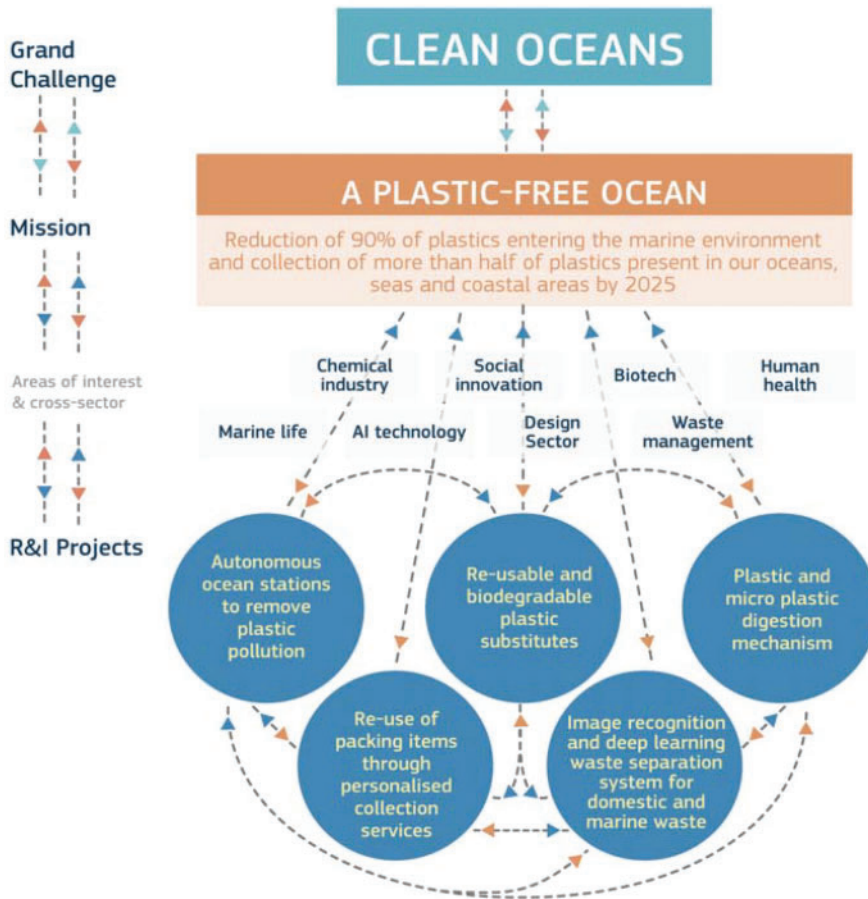
Missions should be framed in such a way as to spark activity across, and among, multiple scientific disciplines (including social sciences and humanities), across different industrial sectors (e.g., transport, nutrition, health, and services), and different types of actors (public, private, third sector, and civil society organizations). Missions need to be chosen to address clear challenges that stimulate the private sector to invest where it would not have otherwise invested (“additionality” in business). By taking a problem focused lens and not a sectoral lens, problems related to sustainability will not just involve, for example, renewable energy, but could also involve transport, strategic design, and new digital solutions, among others. Similarly, problems related to health will not only involve innovation in pharmaceuticals but also in such areas as nutrition, artificial intelligence, mobility, and new forms of digitally enhanced public service provision.

Missions connect all relevant actors through new forms of partnerships for codesign and cocreation by focusing on targets that require multiple sectors and actors to solve. Thus, mission-oriented innovation has the possibility of leading to system-wide transformation.

(5) Multiple, bottom-up solutions

Missions should not be achievable by a single development path or by a single technology. They must be open to being addressed by different types of solutions. A mission-based approach is clear on the expected outcome. However, the trajectory to reach the outcome must be based on a bottom-up approach of multiple solutions—of which some will fail or have to be adjusted along the way.

An example of how the five areas above could be applied to the mission to get plastic out of the oceans is described below.



(1) Bold, inspirational with wide societal relevance

Every year, Europeans generate 25 million tonnes of plastic waste, of which less than 30% is recycled. Plastic makes up 85% of beach litter. There are two strands to tackling plastic ocean pollution. First, existing plastic pollution must be removed from the ocean, and second, new ways must be found to curtail the entry of new plastic waste to the oceans. Drastically reducing the amount of plastic that enters and floats in the oceans will have a substantial impact on the health of European citizens, marine life, and the environment. This mission would be closely aligned with the objectives of the recently adopted Plastics Strategy (European Commission, 2018) creating an important interaction between research and innovation activities and policy development.

(2) A clear direction: targeted, measurable, and time-bound

This mission could have a clear target to reduce the amount of plastic entering the marine environment by 90%, and of collecting more than half of the plastic currently present in our oceans, seas, and coastal areas. This would mean stopping at least 7.2 million tonnes of plastic entering the marine environment and collecting at least 2 million tonnes of plastic per annum from oceans, seas, and coastal areas. A very ambitious, yet achievable timeline to reach this target would be circa 5–10 years.

(3) Ambitious but realistic research and innovation actions

Research and innovation activities across the entire innovation chain would be essential to reach a plastic-free ocean. Research actions would also need to target the reduction of impact of marine litter on human and animal health. Collaboration and feedback loops between basic research (such as chemical research on characteristics of plastic), applied research (such as biotech applications in packaging design), and entrepreneurial innovation (such as on-sea plastic collection stations) will be essential. Such knowledge-based research and innovation could work in conjunction with regulatory and governance actions to see that the mission target is reached.

(4) Cross-disciplinary, cross-sectoral, and cross-actor innovation

Oceans are a source of life for society. Many different actors of society will need to be involved (chemical engineers, marine biologists, marketing experts, environmental scientists, earth observation specialists, fishermen, citizens at large, etc.). These different actors will need to collaborate across sectors such as chemical, biotech, marine life, consumer goods, artificial intelligence, health, design, and waste—while incorporating cross-disciplinary research such as product design, in particular design for the food processing chain (packaging of food), cosmetics, tyres, and textiles.

(5) Multiple, bottom-up solutions

Removing plastics from the ocean is such a large and complex exercise, that it could not be achieved by a single technological (or policy) solution. It will require a combination of various solutions, focusing on different facets of the problem, which will need to be coordinated to reinforce each other. Interaction between projects, and experimentation and risk-taking, can increase additionality. For example, an autonomous ocean plastics management station might take time to implement, but the knowledge base for this station could be used to inform a hybrid, plastics-digestion mechanism, which could be implemented first, possibly in the form of distributed nets. This might kick-start an innovative and more efficient way of overall ocean plastics removal.

## 5. Conclusion: a practical approach to implementing mission-oriented innovation policies

The article opened 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 well-being, and adjusting to demographic changes.

Missions cannot happen without new tool kits. We have discussed the need for policy itself to be seen as market making and shaping rather than just fixing, and the need for particular tools including the use of patient finance, and the ability of state actors to experiment, explore, and build capacities for learning.

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 organizational 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 spillovers that are created across sectors.

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.

Mission-oriented innovation policy is far from being a step into the unknown. As set out in this article, 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 cocreate 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.

## Acknowledgment

This article brings together key insights from an Institute for Innovation and Public Purpose (IIPP) working paper originally published as Mazzucato (2017) and the European Commission report on Missions (Mazzucato, 2018).

## References

- 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), 1742–1756.
- Angell, M. (2005), *The truth about the drug companies: How they deceive us and what to do about it*. Random House Incorporated.
- Block, F. L. and M. R. Keller (eds) (2011), *State of Innovation: The U.S. Government's Role in Technology Development*. Paradigm Publishers: Boulder, CO.
- BMUB (2016), *German Resource Efficiency Programme II*. [http://www.bmub.bund.de/fileadmin/Daten\\_BMU/Pool/Broschueren/german\\_resource\\_efficiency\\_programme\\_ii\\_bf.pdf](http://www.bmub.bund.de/fileadmin/Daten_BMU/Pool/Broschueren/german_resource_efficiency_programme_ii_bf.pdf)
- BNDES (2012), *Apoio À Inovação*. BNDES: Rio de Janeiro, Brazil.
- Breznitz, D. and D. Ornston (2013), 'The revolutionary power of peripheral agencies: explaining radical policy innovation in Finland and Israel,' *Comparative Political Studies*, 46(10), 1219–1245.
- Buchanan, J. M. (2003), 'Public choice: the origins and development of a research program,' *Champions of Freedom*, 31, 13–22.
- Cantner, U. and A. Pyka (2001), 'Classifying technology policy from an evolutionary perspective,' *Research Policy*, 30(5), 759–775.
- Cohen, W. M. and D. A. Levinthal (1990), 'Absorptive capacity: a new perspective on learning and innovation,' *Administrative Science Quarterly*, 35(1), 128.
- Ergas, H. (1987), 'Does technology policy matter,' in *Technology and Global Industry: Companies and Nations in the World Economy*. pp. 191–245.
- European Commission (2011), 'Green paper: from challenges to opportunities: towards a common strategic framework for EU research and innovation funding,' European Commission: Brussels, Belgium.
- European Commission (2018), European Strategy for Plastics. [http://ec.europa.eu/environment/waste/plastic\\_waste.htm](http://ec.europa.eu/environment/waste/plastic_waste.htm) (16 February, date last accessed).
- Foray, D., D. Mowery and R. R. Nelson (2012), 'Public R&D and social challenges: what lessons from mission R&D programs?,' *Research Policy*, 41(10), 1697–1902.
- Foray, D., P. A. David and B. Hall (2009), 'Smart specialisation. The concept,' Knowledge Economists Policy Brief (Expert Group on Knowledge for Growth), No. 9.
- Freeman, C. (1995), 'The 'national system of innovation' in historical perspective,' *Cambridge Journal of Economics*, 19(1), 5–24.
- Fried, L. S., S. Shukla and S. Sawyer (eds) (2012), *Global Wind Report: Annual Market Update 2011*. Global Wind Energy Council (March): Brussels.
- Griffith, R., H. Miller and M. O'Connell (2010), 'Corporate taxes and intellectual property: simulating the effect of patent boxes,' IFS Briefing Note 112, Institute for Fiscal Studies: London.
- Griffith-Jones, S. and J. Tyson (2012), 'The European Investment Bank and its role in regional development and integration,' in M. A. Cintra and K. D. R. Gomes (eds), *The Transformations of the International Financial System*. IPEA: Brasilia, Brazil.
- Hall, B. H. (2002), 'The financing of research and development,' *Oxford Review of Economic Policy*, 18(1), 35–51.
- Hall, B. H. and J. Lerner (2010), 'The financing of R&D and innovation,' in *Handbook of the Economics of Innovation*, Vol. 1. North-Holland: Amsterdam, The Netherlands, pp. 609–639.
- Hirschman, A. O. (1967), *Development Projects Observed*. Brookings Institution Press: Washington, DC.
- Jaffe, A. B., R. G. Newell and R. N. Stavins (2005), 'A tale of two market failures: technology and environmental policy,' *Ecological Economics*, 54(2–3), 164–174.
- Johnson, B. H. (1992), 'Institutional learning,' in B.-A. Lundvall (ed.), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Pinter: London, UK, pp. 23–44.
- Kattel, R. and M. Mazzucato (2018), 'Mission-oriented innovation policy and dynamic capabilities in the public sector,' *Industrial and Corporate Change*, 27(5), 787–801.
- Kerr, W. R. and R. Nanda (2015), 'Financing innovation,' *Annual Review of Financial Economics*, 7(1), 445–462.
- KfW (2015), 2015 Financial Report. Kreditanstalt für Wiederaufbau, Frankfurt am Main: Germany. [https://www.kfw.de/PDF/Download-Center/Finanzpublikationen/PDF-Dokumente-Berichte-etc/3\\_Finanzberichte/KfW-Finanzbericht-2015-E.pdf](https://www.kfw.de/PDF/Download-Center/Finanzpublikationen/PDF-Dokumente-Berichte-etc/3_Finanzberichte/KfW-Finanzbericht-2015-E.pdf)
- Lazonick, W. and Ö. Tulum (2011), 'U.S. biopharmaceutical finance and the sustainability of the U.S. biotechnology business model,' *Research Policy*, 40(9), 1170–1187.

- Louw, A. (2012), 'Development banks: less for green in 2013?', *Renewables Research note*, 2012, Bloomberg New Energy Finance: New York.
- Lundvall, B.-A. (1992), 'Introduction,' in B.-Ö. Lundvall (ed.), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Pinter: London, UK, pp. 1–20.
- Mazzucato, M. (2013), *The Entrepreneurial State: Debunking the Public Vs. Private Myth in Risk and Innovation*. Anthem Press: London, UK.
- Mazzucato, M. (2014), Think piece: "a mission-oriented approach to building the entrepreneurial state", Paper Commissioned by Innovate UK-Technology Strategy Board November 2014/T14/165. <https://www.gov.uk/government/news/long-term-growth-innovations-role-in-economic-success>
- Mazzucato, M. (2016), 'From market fixing to market-creating: a new framework for innovation policy,' *Industry and Innovation*, 23(2), 140–156.
- Mazzucato, M. (2017), 'Mission-oriented innovation policy: challenges and opportunities,' *UCL Institute for Innovation and Public Purpose Working Paper*, (2017-1). <https://www.ucl.ac.uk/bartlett/public-purpose/publications/2018/jan/mission-oriented-innovation-policy-challenges-and-opportunities>
- Mazzucato, M. (2018), *Mission-Oriented Research & Innovation in the European Union. A Problem-Solving Approach to Fuel Innovation-Led Growth*. European Commission, Directorate-General for Research and Innovation: Brussels, Belgium. <https://publications.europa.eu/en/publication-detail/-/publication/5b2811d1-16be-11e8-9253-01aa75ed71a1/language-en#>
- Mazzucato, M. and C. O'Donovan (2016), 'The BBC as market shaper and creator,' in N. Seth-Smith, J. Mackay and D. Hind (eds), *Rethinking the BBC: Public Media in the 21st Century*. Commonwealth Publishing. <http://commonwealth-publishing.com/shop/rethinking-the-bbc-public-media-in-the-21st-century/>
- Mazzucato, M. and C. Penna (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). <https://www.cgce.org.br/the-brazilian-innovation-system>.
- Mazzucato, M. and C. Perez (2015), 'Innovation as growth policy,' in J. Fagerberg, S. Laestadius and B. R. Martin (eds), *The Triple Challenge for Europe: Economic Development, Climate Change, and Governance*. Oxford University Press: Oxford, UK, pp. 229–264.
- Mazzucato, M. and C. C. R. Penna (eds) (2015a), *Mission-Oriented Finance for Innovation: New Ideas for Investment-Led Growth*. Policy Network/Rowman & Littlefield: London, UK.
- Mazzucato, M. and C. C. R. Penna (2016b), 'Beyond market failures: the market creating and shaping roles of state investment banks,' *Journal of Economic Policy Reform*, 19(4), 305–326.
- Mazzucato, M. and G. Semieniuk (2017), 'Public financing of innovation: new questions,' *Oxford Review of Economic Policy*, 33(1), 24–48. <https://academic.oup.com/oxrep/article/33/1/24/2972707/Public-financing-of-innovation-new-questions>
- Mazzucato, M. and L. R. Wray (2015), 'Financing the capital development of the economy: a Keynes-Schumpeter-Minsky synthesis,' Working Paper, No. 837, Levy Economics Institute. [http://www.levyinstitute.org/pubs/wp\\_837.pdf](http://www.levyinstitute.org/pubs/wp_837.pdf)
- Mowery, D. C. (2010), 'Military R&D and innovation,' in B. H. Hall and N. Rosenberg, (eds), *Handbook of the Economics of Innovation*. pp. 1219–1256.
- Mowery, D. C., R. R. Nelson and B. R. Martin (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), 1011–1023.
- Nelson, R. R. (2011), 'The Moon and the Ghetto revisited,' *Science and Public Policy*, 38(9), 681–690.
- Pisano, G. (2006), 'Can science be a business,' *Harvard Business Review*, 10, 1–12.
- Rodrik, D. (2004), 'Industrial policy for the twenty-first century,' John F. Kennedy School of Government Working Paper Series, No. RWP04–047.
- Sampat, B. N. (2012), 'Mission-oriented biomedical research at the NIH,' *Research Policy*, 41(10), 1729–1741.
- Soete, L. and A. Arundel (1993), *An Integrated Approach to European Innovation and Technology Diffusion Policy: A Maastricht Memorandum*. Commission of the European Communities, SPRINT Programme: Luxembourg, Luxembourg.
- Wood, R. (2012), 'Fallen Solyndra won bankruptcy battle but faces tax war,' *Forbes*, (11 June). <http://www.forbes.com/sites/robertwood/2012/11/06/fallen-solyndra-won-bankruptcy-battle-butfaces-tax-war/>
- World Bank (2015), History. <http://go.worldbank.org/65Y36GNQB0> (15 December, date last accessed).
- Wright, B. D. (2012), 'Grand missions of agricultural innovation,' *Research Policy*, 41(10), 1716–1728.