HOW CAN MISSIONS BECOME SUCCESSFUL?

– A LITERATURE REVIEW ON MISSION-ORIENTED INNOVATION POLICY

Rapport

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Published January 2021

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Content

Executive summary

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The concept of missions has pervaded the academic literature on innovation policy in the past decade. Much of the debate is still mostly conceptual although drawing on empirical studies of previous missions in the 20th century as well as grey literature on more recent experiences with implementation of mission-oriented innovation policy (MOIP). MOIP originates from a general recognition of and frustration with significant challenges to society such as climate change and decreasing food security, which continue to persist, despite massive investment in research and innovation. Thus, central to MOIP are the grand challenges of society as the justification for setting a direction for funding policies and innovation efforts.

MOIP represents a break with the prevailing rationale of government innovation policy to fix system failures such as inefficient or missing links between innovation actors and market failures such as the classic example of firms' inclination to underinvest in basic science. Instead, MOIP focuses on correcting the transformation failure of markets, which by themselves are incapable of setting a direction for innovation efforts towards more desirable social change. The rationales guiding MOIP are not purely economic, and the rationale of preventing or compensating for harmful impacts on society, from climate change for example, may even limit economic growth. However, in the literature on MOIP the economic rationale is about setting a desirable direction for economic growth, and possibly even creating new markets.

The definitions of MOIP in the literature are manifold, but center around three defining features. First, missions are used to set a direction for innovation efforts. Second, missions target the grand challenges of society, be they economic, scientific, or societal. Early missions of the 20th century such as the Apollo mission and the Manhattan project were designed to solve technical challenges with clear goals, few stakeholders, and full government funding. Central to such early missions was the expectation that science would deliver answers to the challenges of society. The missions of today, on the other hand, target more complex problems involving technical as well as social challenges and include a much broader range of stakeholders. While science continues to play a central role in addressing the missions of today, it is also disputed as to whether solving missions requires research or not. Moreover, these challenges are often global by nature, as in the case of climate change, pandemics, and the deterioration of soil health. Third, missions are boundary-crossing policies that extend well beyond traditional innovation policies and into other political domains.

How can missions become successful?

Selecting which missions are socially relevant and choosing how to target them through innovation policy is inherently a political and contested business. This literature review focuses on public sector missions and examines three factors that are vital to successfully engaging with such politics: How are missions selected, funded, and governed?

Selecting missions involves seeking legitimate choices. Contrary to the highly centralized mission-oriented policies of the 1950s to 1980s, with goals centrally determined by government institutions, missions of the 21st century call upon a range of stakeholders and decentralized decision processes to address the complex, wicked problems of today. Gathering knowledge on the nature of the challenge is the first step in making informed choices. This involves a broad consultation of stakeholders with knowledgeable insight into as well as stakes in the challenge. This can qualify the wording of the mission, increase the democratic legitimacy needed for society to take ownership of the mission and ensure that it outlasts

individual politicians and governments. Furthermore, the selection process entails setting measurable and time-bound goals and objectives for the mission, preferably broken down into sub-goals and milestones allowing for the evaluation of the progress of the mission. Involving stakeholders, however, is not without risks, as missions can be captured by vested interests, and because too much involvement of users may lead to less radical or disruptive innovation.

Funding for missions must be willing to tolerate high risks, be patient, and come from a variety of public and private sources. It is critical to recognize that fundamental change takes time, even decades, and that substantial financing is required in order to encourage diverse technological advances. Funding for missions should be regarded as an eco-system of financing in which the public part consists of research funding, public venture capital funds, procurement instruments, and public banks. If managed well, the coordination of these financial instruments around missions could not only crowd-in private finance, but also mobilize crowdfunding and philanthropic funding along the full innovation chain. Taking a mission-oriented approach to public investment calls for a keen eye for which part of the innovation chain is insufficiently funded in a particular sector. This is an analysis which requires a deeper understanding of the market than simply funding good projects and imposing economy-wide standards.

Governing missions is a continual process of balancing centralized decisions about goals and priorities with the need for engaging a wide range of decentralized public and private sector initiatives. This requires a public sector with more dynamic capabilities to engage in new forms of collaboration beyond traditional policy practice; an unprecedented ability to coordinate policy initiatives and efforts across policy levels, fields of ministerial responsibility, and social actors; and an ability to experiment with and continuously evaluate the political toolbox as an instrument for constant learning and adaptation as projects and programs progress and eventually succeed or fail.

Coordinating missions, however, is not a straightforward task, but a matter of negotiating with path-dependent structures of political institutions as well as the myriad of political interests and considerations, all of which constitute a society. Prior experiences with integrated policy strategies targeting challenges such as decreasing food security and climate change are almost exclusively reports of failure, a lesson which should give rise to serious consideration of the scope of the task faced by government when pursuing MOIP.

Much of the literature on MOIP is preoccupied with how political instruments for increasing society's demand for and diffusion of new technologies can supplement support for research and technology development projects. The focus on the effect of a policy mix rather than a single instrument is a useful reminder of the need for reflecting on the rationales of each instrument as well as the trade-offs between different instruments and the way they impact the goals of innovation policy. This is pivotal when designing MOIP as missions span financial, regulatory, and soft instruments such as seeking democratic legitimacy and engaging stakeholders. They require considerations of the design of supply-side policies such as research and development programs supporting development and deployment of many different technologies, as well as demand-side policies such as public procurement and regulatory policies used for promoting certain technologies or solutions. It is important, however, to recognize that across missions or sectors, there is no one-size-fits-all innovation policy.

Evaluation of missions should move away from traditional cost-benefit analyses and seek a wider understanding of the value public policies can create. Evaluation should be concerned with portfolios rather

than simple projects or instruments. Rather than a tool for justifying public intervention through simple cost benefit analyses, evaluation should be continuous, used for constant learning and adaptation. However, the literature presents little knowledge on whether and how such complex evaluation can actually be undertaken.

About the review

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This review is written for a policy audience with the aim of investigating the nature and history of mission-oriented innovation policy (MOIP) as well as the factors influencing the success of said policy.

The review was undertaken using SCOPUS database for identifying peer-reviewed literature as well as Google for identifying grey literature. All relevant literature was coded through NVIVO Qualitative Data Analysis Software using predefined coding categories in accordance with the aim of the review. Throughout the coding process, additional subcategories where added.

SCOPUS was chosen as the database for searching peer-reviewed literature on MOIP as it contains all top 20 journals citing core contributions from two of the most relevant fields, Science and Technology Studies (STS) and Innovation Studies, previously identified by Martin, Nightingale, and Yegros-Yegros (2012) and Fagerberg, Fosaas, and Sapprasert (2012).

A search was initially performed on SCOPUS in June 2020 using the following search terms:

> TITLE-ABS-KEY (("Strategic research" OR "Strategic innovation" OR "Strategic R&D" OR mission* OR "transformative research" OR "transformative innovation" OR "Transformative change")) OR TITLE-ABS-KEY (("challenge-oriented" OR "challenge-driven" OR "challenge-based" OR "grand challenge*" OR "societal challenge*" OR "Manhattan Project" OR "Apollo Program")) AND TITLE-ABS-KEY (("innovation system*" OR "Innovation polic*" OR "research polic*" OR "technology polic*" OR "socio-technical" OR "mission R&D program")

The search produced a recall of 643 publications, which was subsequently filtered by a review of relevant titles and abstracts reducing the total number of publications to 66. The search on SCOPUS was repeated on December 3rd 2020 bringing the total number of relevant peer-reviewed publications from the SCOPUS search to 74.

From August to December 2020 continuous snowballing from the peer-reviewed literature supplemented with searches performed on Google for grey literature added new publications to the list. In a few instances, the search has moved slightly beyond the literature on MOIP, namely where the literature has offered limited insight into concepts central to the topic.

1 What is mission-oriented innovation policy?

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Missions have become the talk of the town in research and innovation policy circles. Inspired by the famous missions of the past – like NASA's Apollo mission and the Manhattan Project – missions have become fashionable again and have spurred a new optimism about how states can stimulate and give direction to innovation (Borrás and Edler 2020). But in contrast to the predominantly technical missions of the past, the present attempts to instrumentalize science and innovation are mostly directed towards solving more complex societal challenges, like climate change or the ageing society (Coenen, Hansen, and Rekers 2015; Mazzucato 2016). Today, most of the literature continues to ascribe science a central role in pursuing the goals of modern missions, but at the same time it is contested: is science necessary for solving the missions of today? This new challenge-orientation has even been named the 'next generation' of science, technology and innovation policy (Kuhlmann and Rip 2018).

Box 1 // Recent and current examples of mission-oriented innovation policy

Below are recent or current examples of mission-oriented innovation policy. Given the variety of definitions and disagreement about what constitutes a mission, these are broad examples which at least to some degree have the characteristics of missions.

Country/region	Example of missions	Period
Belgium	The Circular Flanders Initiative	2012-2020
EU	Active and Assisted Living Programme	2013-2020
	Conquering Cancer: Mission Possible	2021-2030
	A Climate Resilient Europe	2021-2030
	Mission Starfish 2030: Restore our Oceans and Waters	2021-2030
	100 Climate-Neutral Cities by 2030	2021-2030
	Caring for Soil is Caring for Life	2021-2030
Japan	Hydrogen Society	1991-2040
China	New Energy Vehicles	2001-2020/2025
The Netherlands	Delta Plan	1953-2050
	Top Sectors	2018-present
Norway	The Norwegian EV Initiative	1989-2025
UK	The Grand Challenge missions	2019- present
	Clean Air London	1999- present
Sweden	Mission-oriented initiatives targeting food and mobility (Vinnova)	2019- present
Germany	The High-Tech Strategy	2006- present
	Energiewende	2010- present
USA	The Brain Initiative	2013- present
	Cancer moonshot	2016-2023
	SunShot Initiative	2011-2030
Austria	KIRAS – Sicherheitsforschung	2005-2020

Sources: (Joint Institute for Innovation Policy et al. 2018; Kuittinen and Arrilucea 2018; The Brain Initiative 2019; Publications Office of the European Union 2018b; 2018c; 2018a; Department for Business, Energy & Industrial Strategy 2019; Vinnova 2021; Ministry of Economic Affairs and Climate Policy 2019)

Currently, and historically, there are and have been numerous attempts all over the world to develop missions, including the EU, for whom the economist Mariana Mazzucato has laid down the theoretical framework (Mazzucato 2018a) underpinning the 5 missions currently pursued by the EU (e.g. on adapting to climate change). See examples, including the EU missions, in box 1.

MOIP is also a burgeoning research field, with engagement from many sub-fields and with diverse theoretical underpinnings. Much of the debate is still mostly conceptual although drawing on empirical studies of previous missions in the 20th century as well as grey literature on more recent experiences with implementation of MOIP. Much of the debate is driven by the necessity of addressing the grand challenges of today and thus transforming society towards having a lesser imprint on climate and the environment, coping with an ageing society, securing healthy oceans and soil for future food production etc. However, what defines mission-oriented innovation policy is contested, has changed over time and is still underexplored in the science, technology, and innovation literature (Janssen et al. 2020). The concept has no formal definition in the OECD Frascati Manual (Georghiou 2018). And while it can be regarded as a type of innovation strategy – for which we can define success factors, proper governance arrangements, etc. – it can also be regarded merely as narrative for challenge-oriented policies (Janssen et al. 2020).

In this report we review the literature on MOIP. We investigate the drivers and rationales behind missions, synthesize attempts to define the concept, and try to find evidence for mission success factors.

1.1 Drivers and rationales

In this section we attempt to synthesize what the literature identifies as the drivers and rationales behind the current interest in missions all over the world. The section points to the framing of societal challenges as a central driver, especially the types of challenges which are 'wicked' in nature and urgent, and are put forward as justifications for missions. Furthermore, we observe a shift from a 'market failure' justification of supporting basic research and a 'system failure' justification of supporting links between central innovation actors, to a 'transformation failure' justification, in which there is an emphasis on the inadequacies of the market in giving societally desirable direction to innovation efforts. We then argue that there is still an economic rationale behind mission efforts (even though the purely economic rationale of previous innovation policies is criticized in the transformative innovation tradition). Lastly, we argue that framing efforts as missions might aim to mobilize support for innovation because missions are easier to communicate.

1.1.1 Societal challenges call for missions

The central drive behind the increasing interest from policy and research in missions is the framing of societal challenges. Societal challenges are used, more generally, as a rationale for setting the direction for innovation. As Mazzucato puts it, "...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" (Mazzucato 2018b, 804). As Borrás and Edler point out, there is frustration in society and among policy makers that challenges like climate change and antibiotic resistance continue to persist, despite massive investment in research and innovation (Borrás and Edler 2020). Interestingly, frustration with our inabilities in addressing important societal issues with science and technology is not new. Back in 1977, Richard R. Nelson published the book "The moon and the Ghetto", in which he asked the puzzling question of how we were able to land a man on the moon but still struggle with how to solve the problems in ghettos. The answer, according to Nelson, was that

landing a man on the moon was a purely technical feat, with a clearly defined objective, few stakeholders and solely government funded (Ulnicane 2015; Boon and Edler 2018).

Some argue that our current world face more challenges like those of the ghetto (Diercks, Larsen, and Steward 2019), and that these are 'wicked' problems, in the sense that they are complex and hard to solve. Whether we have more so called 'wicked' problems today than before is of course hard to establish. Furthermore, what constitute societal challenges – and more broadly 'public value' – is not a given, but represents the sentiments and values of those actors that are involved in and deemed responsible for determining them. Challenges might be interpreted rather differently between actor groups and between countries and regions in the world (Uyarra, Ribeiro, and Dale-Clough 2019). Hence, determining what challenges to pursue with missions is in the end a political question. One of the strong forces behind societal challenges entering the political agendas around the world, and also in the realm of innovation policy, has been the United Nations (UN) Sustainable Development Goals from 2015 (Borrás and Edler 2020). The specific challenge of climate change has been an important accelerator of mission thinking in particular (Diercks, Larsen, and Steward 2019).

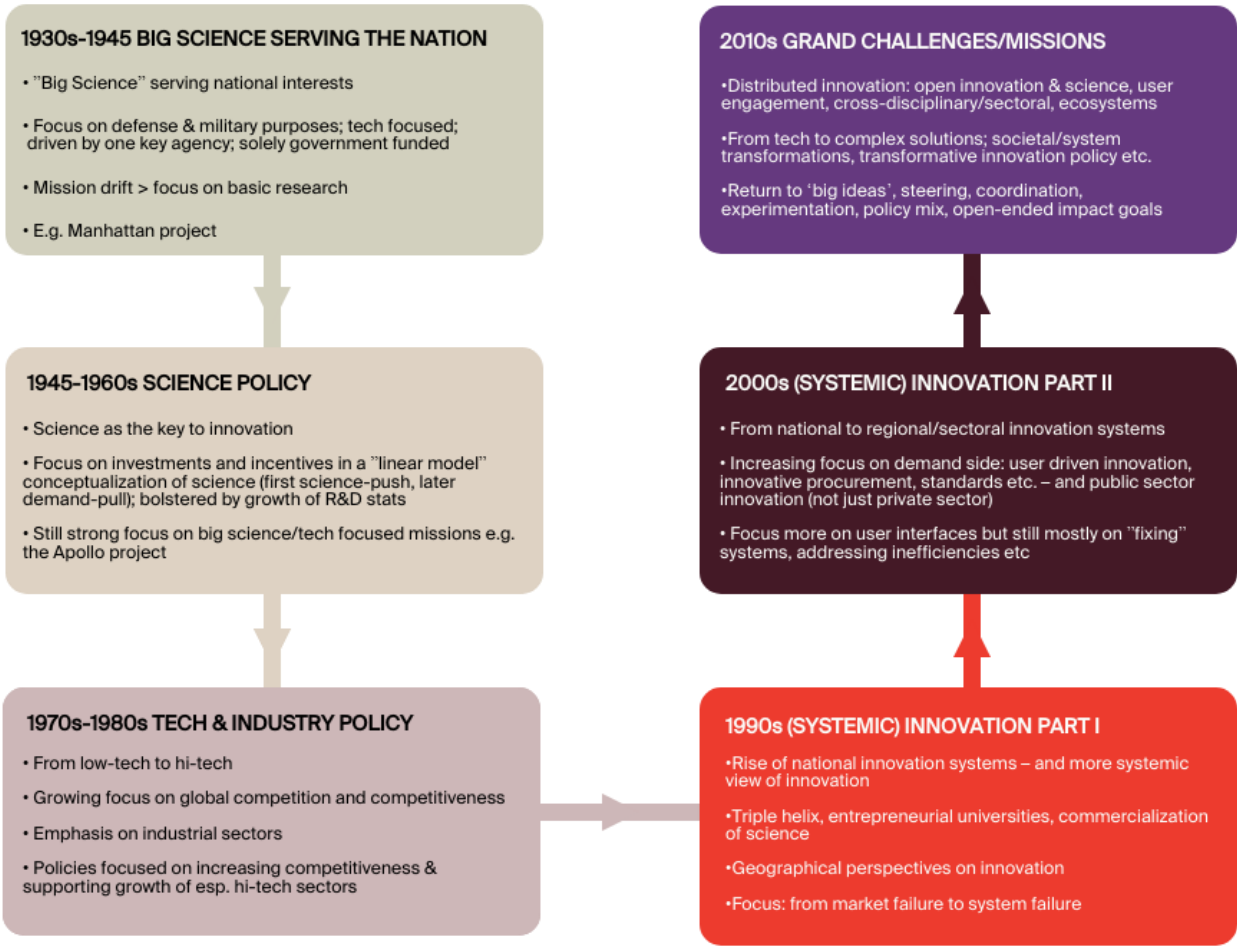
The nature of current challenges is one of the important rationales behind the current enthusiasm towards missions: "...they [challenges] are complex, open-ended, uncertain/unpredictable, multidimensional and systemic. This 'wicked nature' is the raison d'être of 'new' MOIPs [Mission-Oriented Innovation Policies] as they require a new type of policy approach, better coordinated and targeted" (OECD 2019, 20). The literature quite unambiguously points to the wickedness of today's challenges as an important argument for thinking seriously about undertaking missions (Cagnin, Amanatidou, and Keenan 2012; OECD 2019; Mazzucato 2018b; Cagnin, Amanatidou, and Keenan 2012; Borrás and Edler 2020; Boon and Edler 2018; Coenen, Hansen, and Rekers 2015; Janssen et al. 2020). Simply put, because challenges today are of a different nature to the challenges that inspired the Apollo program and the Manhattan Project, missions need to take new forms. We will discuss how the nature of wicked problems shapes how missions are defined in section 1.2 on mission definition.

1.1.2 From market and system to transformation failure

The current mission efforts also reflect a shift in the theoretical foundation of innovation policies. In short, the discussion has moved from solely thinking in terms of fixing 'market failures' (e.g. focusing investments on basic science, which private companies have little incentive to pursue on their own) to also fixing 'transformation failures' (i.e. aiming broader policies towards societal transformation).

Historically, governments have invested especially in basic research, based on a market failure rationale (Robinson and Mazzucato 2019a; Mazzucato 2016). Based on neoclassical economy theory (Mazzucato, Kattel, and Ryan-Collins 2020), market failure occurs when the behavior of rational, self-interested individuals leads to inefficient distribution of goods in a free market. A common example of this, which is especially relevant for science and innovation policies, is the issue of public goods. Public goods, like defense and also basic science, suffer from a lack of incentive for any one person or company to invest in them, because others would also benefit from them (Weber and Rohracher 2012; Robinson and Mazzucato 2019a). The argument for basic science belonging to this category is that any one person's (or company's) use of knowledge would not preclude another from using that same knowledge. For this reason, rational private companies would underinvest in basic science because they would not be able to profit from creating knowledge that would eventually become readily available to everyone (Fagerberg 2017).

Figure 1 // The history of innovation policy



Source:Lundvall and Borrás 2006; Luc Soete 2007; D.C. Mowery 2009; David C. Mowery, Nelson, and Martin 2010; Fagerberg 2015; 2017; Kattel and Mazzucato 2018; Diercks, Larsen, and Steward 2019

However, the market failure argument, in relation to innovation policy, would be challenged by the proliferation of innovation system (IS) thinking during the 1990s especially (Fagerberg 2017). In IS theory, the premise is that innovation is a social and systemic endeavor, which requires a range of actors to work together in a concerted manner (Fagerberg 2018). In a system perspective, failures would not be limited to market failure, but would also entail 'system failure', in the sense that inefficient or missing links between actors would hamper innovation (Coenen, Hansen, and Rekers 2015; Uyarra, Ribeiro, and Dale-Clough 2019). In these cases, government intervention would be legitimate.

Nevertheless, both the 'market failure' and 'system failure' rationales have in recent years been challenged. Scholars have criticized those lines of thinking for not being able to take into account a desirable direction of innovation efforts. Robinson and Mazzucato describes the 'market failure' rationale as *"...most useful for describing a steady-state scenario in which public policy aims to put patches on*

existing trajectories provided by markets" (Robinson and Mazzucato 2019a, 937). Similarly, the system failure rationale has been criticized for favorizing existing actors and institutions, making more radical changes to the entire system less likely (Frenken 2017). Both rationales focus merely on optimizing markets (instead of transforming them) and suffer from an inability to handle a desired direction of innovation, which is why Weber and Rohracher suggested the now widely used term 'transformation failure' (Weber and Rohracher 2012). The concept covers four types of failures: Directionality failure (lack of goal and direction of transformation process), demand articulation failure (insufficient anticipation and learning from user needs), policy coordination failure (lack of multi-level policy coordination) and reflexivity failure (inability to monitor progress and adapt to change) (Weber and Rohracher 2012, 1044).

It is important to underline that although the concepts of market, system and transformational failures have a historical dimension in terms of their development, they are all still employed as rationales for interventions (Borrás and Edler 2020; Robinson and Mazzucato 2019a). Hence, they are layered ideas instead of succeeding paradigms.

1.1.3 Economic growth

Making nations or regions more competitive and securing economic progress have for decades been a key driver for innovation policies (Fagerberg 2017; Borrás 2011). In the pursuit of economic gains, unfortunately, markets have also supplied the world with innovations that contribute negatively to the total welfare, e.g. due to negative environmental effects (Coenen, Hansen, and Rekers 2015; Boon and Edler 2018). The focus in current mission efforts towards societal transformation represent, at least to some extent, a reaction to a purely economic goal of innovation policy (Diercks, Larsen, and Steward 2019): Public value is, in the end, more than just economic growth (Mazzucato, Kattel, and Ryan-Collins 2020).

It would, however, be a misunderstanding if one sees current mission initiatives as having no economic rationales. In fact, some argue that missions are a way for governments to create new markets for potential economic growth (Mazzucato and Semieniuk 2017). By affecting companies' expectations as to where future growth will take place, missions have the potential to crowd in private investments in research, development and innovation (Mazzucato 2018b). As Mazzucato et al. put it, "...it is about providing a direction for growth" (Mazzucato, Kattel, and Ryan-Collins 2020, 432).

Mission-oriented programs have also been instrumental in pioneering new technology that has, later on, proved to have great market potential. As Mazzucato and Semieniuk explain: "...all of the technologies that have made Apple's i-products (iPhone, iPad, etc.) 'smart' were initially funded by different mission-oriented 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 again" (Mazzucato and Semieniuk 2017, 29). In other words, economic rationales are still very present in current rationales behind missions.

1.1.4 Mobilizing support for innovation

Missions have also been highlighted as ways of mobilizing people, resources and institutions and to create a sense of urgency around the challenges addressed by missions (Janssen et al. 2020). And one of the rationales behind the EU move towards working on missions is that it can communicate to citizens that the innovation efforts of the union can actually contribute to solving societal challenges that are important to them (The Joint Institute for Innovation Policy et al. 2018). Specifically, Grand Challenges was introduced for the purpose of promoting the European Research Area (ERA) around 2008 (Ulnicane

2015). In that sense, missions can be seen as a means of securing input legitimacy (i.e. social acceptance of the initiation of policy initiatives as a response to certain pressing societal challenges) rather than output legitimacy (the actual or expected outcome of a policy initiative) (Boon and Edler 2018).

1.2 Definitions

In this section, we review the literature on defining traits of missions. We synthesize three traits of missions that we find are so widespread in the literature that they might serve as a basis for a broad definition. We find that missions are a) directed, b) challenge-oriented, and c) boundary-breaking.

Box 2 // Definitions of missions and related concepts

"Based on the literature and our empirical findings, we define mission-oriented research and innovation initiatives as large-scale interventions aiming for a clearly defined mission (i.e. goal or solution) to be achieved." (Joint Institute for Innovation Policy et al. 2018, 2)

"Mission-oriented policies can be defined as systemic public policies that draw on frontier knowledge to attain specific goals" (Mazzucato 2018b, 804)

"...we view MIP [Mission-oriented Innovation Policy] as a directional policy that starts from the perspective of a societal problem, and focuses on the formulation and implementation of a goal-oriented strategy by acknowledging the degree of wickedness of the underlying challenge, and the active role of policy in ensuring coordinated action and legitimacy of both problems and innovative solutions across multiple actors" (Wanzenböck et al. 2020, 2)

"...mission-oriented research and innovation policies (MOIPs) are defined in this project as a co-ordinated package of research and innovation policy measures aiming to address societal challenges. They possibly span different stages of the innovation cycle from research to demonstration, cut across various policy fields and are implemented in order to meet ambitious and concrete goals in a defined timeframe." (OECD 2019, 7)

"The role of mission-oriented policies is to translate broad challenges and political orientations [...] into "doable" problems to be solved" (Mazzucato and Robinson 2018, 936)

"policy-led attempts to engage a (wide) spectrum of stakeholders around a particular goal, with the objective of activating and/or catalyzing these stakeholders' (innovative) activity in service of that goal" (Janssen et al. 2020).

Given the number of articles and reports on the subject of missions, there are surprisingly few that offer a short, concise definition of the concept of missions – or related concepts (see box 2 for the clearest examples of actual definitions). Most contributions, though, offer some clues as to what we can understand by missions and related concepts by either implicitly defining concepts or by merely describing approaches to missions. Therefore, in the following sections, we discuss what defines missions by looking at the most widespread ideas about what the concept entails. In some cases, the definition will in fact depend on what kind of mission one is pursuing, and we can, instead of narrowing down one definition, speak about types of missions. Missions can also have a focus on only a selection of the features associated with missions (e.g. not all missions are boundary-breaking or have a clear direction).

It is important to understand that such definitions sometimes seem to stem from empirical observations of how missions have been done (descriptive definitions), and sometimes stem from theoretically derived normative prescriptions of how missions ought to be defined (prescriptive definitions). Furthermore, often it is not possible to deduct from the specific contributions to the literature whether it is one or the other.

Some definitions are rather broad and inclusive, as the one championed by the report written by the Joint Institute for Innovation Policy for the European Commission, in which MOIP is defined simply as interventions aiming for a clearly defined mission (see box 2). Others are more specific and developed, like the one used by Wanzenböck et al. below (see box 2). Some definitions address research and innovation as the sole-contributor to missions (e.g. the OECD definition from box 2), while others acknowledge broader contributions (e.g. the Mazzucato definition from box 2). Some mission-definitions operate with a narrow understanding of the challenges they pursue while others operate with a very broad understanding. Finally, some definitions entail specifications of mission selection, governance, size and other traits one might attribute to missions.

1.2.1 Directionality

If there is one trait that most definitions of missions have in common, it is 'directionality'. Missions, scholars unanimously argue, set a clear direction for innovation efforts. In one definition, directionality and intentionality are in fact core features of what sets missions apart from other research and innovation policy initiatives (Joint Institute for Innovation Policy et al. 2018). Setting direction is, however, not about top-down planning or 'picking the winners', but about "...increasing business expectations about future growth areas and catalysing activity – self-discovery by firms – that otherwise would not happen" (Mazzucato, Kattel, and Ryan-Collins 2020, 423). Hence, setting direction does not necessarily involve choosing a specific technology (the means) but could be confined to merely setting a direction (the goal).

In practice, directionality typically involves setting goals or targets to be pursued in the mission. In terms of defining missions, the specification and measurability of goals/targets can vary. Some missions are defined quantitatively (e.g. an X percent reduction in CO2 emissions by a certain milestone) as "one offs" (putting a man on the moon) or as less measurable goals (cleaner oceans) (European Commission 2017). The latter might not even count as 'setting direction', as this type of goal will not distinguish the mission from more conventional research and innovation programs with a rather 'soft' orientation. Setting a goal typically also involves setting a deadline for meeting that goal (Hayter and Link 2020). Hence, missions are also typically time-bound (although, in practice, missions have often been extended) (Joint Institute for Innovation Policy et al. 2018; Mazzucato 2018a).

We will discuss mission selection, including giving direction and setting goals for missions, as one of the factors of mission success in section 2.1 of this review.

1.2.2 Challenge-orientation

Most definitions have challenge-orientation as a central aspect of the concept (e.g. definitions in box 2 above). Broad definitions of this challenge-orientation include both economic, scientific and societal challenges as possible challenges that missions can be directed towards contributing to (Georghiou 2018). In such a broad definition, the very technological missions of the past – e.g. the Apollo project – would also be included. However, many definitions identify broader societal challenges, of a more 'wicked' nature, as the object of modern missions (again, see examples in box 2). In fact, scholars have argued that it is fruitful to use a typology of missions, to handle the different kinds of challenges that

missions can pursue (rather than assigning only one type of challenge-orientation to the mission concept). One such typology discriminates between so called 'accelerator missions' and 'transformer missions'.

On the one hand, we have accelerator missions which are typically technical or scientific in nature and aim at speeding up innovation in an area with rather well-defined objectives. Historical missions like the Apollo project or the Manhattan project are examples of this type of missions, but also more recently deployed missions like ebola-vaccine development or missions to combat cancer resemble this type of mission. Transformer missions, on the other hand, involve targeting 'wicked' problems which necessitate transformative change on a system level. These include missions like mitigating or adapting to climate change, combating poverty, etc. (OECD 2019; Joint Institute for Innovation Policy et al. 2018).

Similar typologies have been suggested by others, distinguishing between type 1 and 2 missions (Robinson and Mazzucato 2019a) or type A and B missions (Georghiou 2018).

1.2.3 Boundary-crossing policies

Mission policies break, cross and expand traditional boundaries of innovation policies in various ways, including actors, sectors, disciplines and between supply-side and demand-side policies. This characteristic of missions is closely related to the 'wicked' character of challenges: Because societal challenges often are systemic and cross many sectors it is necessary to address them across all of these boundaries e.g. across boundaries of ministerial areas of responsibility. As Coenen et al. explain: "Firstly, they [problems/challenges] are complex and multi-sided. Multiple causes and consequences co-exist often covering several societal domains. Secondly, they are uncertain and unstructured. Wicked problems defy easy solutions, and reducing uncertainty by producing more knowledge is not always possible. One partial solution at one point in time may generate new, additional problems at a different point in time or elsewhere. Thirdly, they are difficult to manage. Many different actors are involved that represent different interests, have different problem perceptions and advocate different solutions." (Coenen, Hansen, and Rekers 2015, 484). These characteristics call for policies that break, cross or expand a number of boundaries which are elaborated on in section 2.3 of this review.

1.2.4 Other possible definition characteristics

The above characterizations of missions are the ones that we have found to be broadly represented in definitions of missions and in empirical descriptions of missions. However, there is a host of characteristics that are mentioned in various studies but are not widespread enough to include in a definition of missions. First, some define missions as large scale initiatives, although it is unclear when an initiative would be characterized as "large scale". Budgets in current or past mission initiatives range from millions to several billion (Joint Institute for Innovation Policy et al. 2018). Secondly, some definitions of missions emphasize a decentralized governance structure (Robinson and Mazzucato 2019b), but this is not a defining trait in most definitions (another question is what kinds of governance arrangements are antecedents of success, which we will cover in chapter 2). Another feature of missions highlighted by some scholars is that they are long-term. However, current or past missions vary significantly in their duration (Joint Institute for Innovation Policy et al. 2018) (again, another question is what timeframes mean for mission success, which is discussed in section 2.2).

2 How can missions become successful?

2 How can missions become successful?

Setting the direction for innovation policy through socially relevant missions is inherently a political and contested business (Sorokins, Griniece, and Dudek 2018; Bugge et al. 2017). Choosing what challenges to target and which missions to focus on means prioritizing resources on some issues at the expense of others. Herein lies a conflict of interest (Grillitsch et al. 2019), where local or national industries may very well be prioritized at the expense of international interests (Boon and Edler 2018), and where MOIP initiatives within the same region or nation may even have contradictory objectives (The Joint Institute for Innovation Policy et al. 2018). As an example of the latter, national energy policy may prioritize supporting the fossil fuel industry aiming to strengthen national energy security and at the same time be in direct contradiction to the goals of furthering renewable energy. Furthermore, disputes can arise because of opportunities and threats from innovation, which may be very different across businesses, users or society at large, thereby potentially causing barriers to the diffusion of technological, social, or institutional solutions (Wanzenböck et al. 2020).

Setting a coherent and quantifiable goal in this political arena is an essential factor for the success of missions (Mazzucato 2018a; The Joint Institute for Innovation Policy et al. 2018). This means having an actual strategy for pursuing the mission, a strategy which on the one hand allows for high degrees of autonomy to allow experts to engage in implementing the mission, and on the other hand ensures that efforts to address the challenge are not too disconnected from each other (Anadon 2012). This inherent tension – between setting the direction and allowing for multiple parties and skills to identify the way to get there – is at the core of contemporary mission-thinking addressing wicked, complex problems, whose solutions are beyond the control of one single institution, as previously discussed in chapter 1.

Whereas old-fashioned, mission-oriented research policy of the 1950s to 1980s was characterized by a high degree of centralization, with goals centrally determined by government institutions, missions of the 21st century call for freedom to experiment, decentralization, and local decision processes (European Commission 2017). This in turn calls for patient and high-risk capital (Mazzucato and Semieniuk 2017), as well as new capabilities when governing and evaluating ambitious, long-term missions (Kattel and Mazzucato 2018).

The following chapter will take a closer look at three of the most important factors for the success of MOIP: how missions are selected, funded, and governed.

2.1 Selecting missions

A mission is a means to solving challenges. Hence, choosing a mission begins with looking at the most pressing challenges of our time and choosing one or more to pursue with mission(s). Often, focusing in on challenges to address is a diffuse process, with multiple actors involved and discussions taking place in various political forums (OECD 2019). Choosing between challenges, and ultimately missions, is an inherently political and normative endeavor and involves deciding that some challenges are more important and more demanding of our attention and resources than others (Boon and Edler 2018). Therefore, selecting missions may involve dispute and even conflicts between differing interests (Uyarra, Ribeiro, and Dale-Clough 2019; Wanzenböck et al. 2020). The selection process is extremely important since the way a challenge is framed to some extent predetermines what kinds of solutions the missions will evoke (Boon and Edler 2018).

2.1.1 Gathering knowledge

An important step towards mission selection is collecting and generating knowledge and intelligence to inform the choice. First of all, it is important to gather the scientific evidence concerning problem causes and consequences, before choosing a mission. The issue is, of course, that such evidence is never complete, nor is it possible to deduct from the evidence a desired direction (Wanzenböck et al. 2020). Secondly, the choice of missions can be informed by various future-oriented forms of intelligence like foresight instruments, technology assessment exercises, technology roadmaps, megatrend analysis etc. (Boon and Edler 2018; European Commission 2017). These kinds of instruments also come in participatory forms, in which the inclusion of a wide range of stakeholders is ensured (Wanzenböck et al. 2020; Boon and Edler 2018). Lastly, and related, involving stakeholders is also a means for gathering knowledge.

2.1.2 Involving stakeholders

Selecting missions is, as mentioned, a highly political affair, often with many opposing interests at play. In contrast to more conventional innovation policies – in which broad support is made available, agnostic to technologies, sectors or scientific disciplines – missions involve setting a clear direction, thereby selecting some areas, and not others, to focus on. Missions even go beyond the also quite conventional sector policies – in which certain sectors are singled out for special attention – because they choose which problems or challenges to focus on. Thus, government also faces a democratic issue when selecting missions (Mazzucato 2018b; Kuhlmann and Rip 2018), and therefore must design a selection process that ensures legitimacy of the mission. The necessity of broad inclusion of various actors and stakeholders, and also civil society, in the selection process, is one of the key points across the academic and grey literature on missions (Diercks, Larsen, and Steward 2019; European Commission 2017; Georghiou 2018; Jütting 2020; Mazzucato 2018b; OECD 2019; Wanzenböck et al. 2020).

Having wide representation included in mission selection is not just about ensuring legitimacy, but also for more functional reasons. First, because of the wicked nature of challenges pursued by missions, framing problems is a difficult task. Broad representation of actors ensures that a diverse set of arguments and problem framings are available before convergence on challenge and mission selection is reached (Wanzenböck et al. 2020). Secondly, an important argument for also bringing in the public/civil society in the selection process is that it ensures demands articulated. The public, in the role of consumers, are central to new innovations being adopted and diffused (OECD 2019; Joint Institute for Innovation Policy et al. 2018; Salas Gironés, van Est, and Verbong 2020). Third, involvement of the public not only furthers society taking ownership of the mission, but it also supports missions lasting longer than individual ministers and governments (Mazzucato 2019).

Securing broad participation of actors in the selection process can be achieved in a variety of ways. First, as mentioned above, future-oriented intelligence gathering can be done with broad participation. Secondly, the public can be engaged early in the exploratory phases of the selection process, e.g. through workshops, living labs, etc. (Sorokins, Griniece, and Dudek 2018). Thirdly, policy makers can engage the public through digital polling or voting in the selection process (Georghiou 2018).

As yet, there are few examples of ongoing MOIP engaging citizens, although their role is argued to be of key importance to missions. Despite efforts to include them, citizens are often left out or reduced to the role of end-users or consumers (Joint Institute for Innovation Policy et al. 2018). One example of an

explicit attempt to involve citizens in the formulation of missions is found in the current work of Vinnova, the Swedish Innovation Agency.

2.1.3 Setting goals

Selection also involves setting goals, targets or objectives for the mission. Setting goals is in fact defining for the mission, since this will be leading all efforts throughout the mission. However, as previously discussed in section 1.2 on definitions, missions range from very narrow to very broad, and, thus, the first step is to find the right 'granularity' of the mission objectives (Mazzucato 2018b; 2019). The overall challenge a mission is meant to address, is too broad to serve as a goal for a mission (e.g. eliminate poverty, stop global warming, etc.). Instead, challenges need to be broken down so they are manageable (Boon and Edler 2018). What the right level of granularity is, is hard to define a priori – although it sits somewhere between the broad challenges and the concrete projects (Mazzucato 2018a).

After selecting the granularity of the mission, the more concrete target or mission goal must be formulated. Mariana Mazzucato argues that in order for missions to be successful, goals must be measurable (Mazzucato 2019; Georghiou 2018). Setting measurable goals is an effective way of setting direction to efforts in a mission and – provided that said goals are time-bound – helps to foster a sense of urgency around the goals. Furthermore, an argument for measurability is that it facilitates accountability. If the goal is unclear or vague, it is impossible to evaluate whether the missions were a success (European Commission 2017). And the more an overall goal can be broken down to sub-goals and milestones, the easier it is to evaluate the progress and ultimately success of the mission (Mazzucato 2018b). It does not necessarily have to be measurable in quantitative terms. For example, developing a vaccine for a virus would be measurable without being quantitative.

2.1.4 Risk of capture

Some of the often-mentioned risks and pitfalls in the mission selection process are different forms of capture. Capture is here understood as when some actor or event influences the selection process too heavily. First of all, there is the risk that challenges will be captured by fashion. That is, if some challenges quickly rise to the policy agenda but then subside (like for example Avian Flu). Fashion might also affect how a persistent challenge is framed. That is why a mission must be flexible enough in order to change as our perception of the underlying challenge evolves (European Commission 2017). Secondly there is the risk of capture a by vested interest if missions are too broad (Mazzucato 2018b) or if there are diverging perceptions of the problems related to the underlying challenge (Wanzenböck et al. 2020). In these cases, there could be room for powerful lobby actors to define the scope of missions in a way that is more to their own than society's benefit. Third, there is the general risk of capture if too much emphasis is on the involvement of users (both companies and other user groups). These actors have a tendency to value short-term value creation (D. Foray, Mowery, and Nelson 2012) and may therefore lead to less radical and disruptive innovation (Grillitsch et al. 2019).

2.2 Funding missions

Public funding is the main source for – although private funding is integral to the success of – missions when looking across current and past MOIP initiatives in the European Union and its main trade partners (Joint Institute for Innovation Policy et al. 2018). But what is the role of public and private funding for missions?

Finance for supporting MOIP must be willing to tolerate high risks, be patient, and come from a variety of public and private sources (Mazzucato and Semieniuk 2017). This should reflect the characteristics of innovation, which can be described as highly uncertain, having long lead times, being the product of a collective process involving different actors operating in different parts of the economy, and being the product of a cumulative effort which "makes the innovation process highly dependent on access to financial resources that will sustain the innovation process from the time at which investments are made until it can generate financial returns" (Lazonick and Mazzucato 2013, 1101). Furthermore, Mazzucato and Semieniuk (2017) argue that private funding has increasingly become risk averse and less patient, focusing instead on short-term goals such as maximizing shareholder values, e.g. through share buybacks. Consequently, public funding plays a key role in providing high risk and patient capital. Supplying such capital inevitably also entails that the government – acting as lead risk taker – will end up funding successes as well as failures.

Understanding who finances what is essential to effectively setting the direction of missions. This is not merely a matter of understanding the role of public versus private funding, but a matter of being able to pinpoint the role of specific financial actors such as state banks, industrial firms, and government agencies in financing particular sectors in different countries (Mazzucato and Semieniuk 2018). Such analysis should seek to understand which actor finances risk related to innovation in firms' research phase, development phase and deployment phase. The argument goes beyond the more traditional focus of public organizations on understanding, which generic market failures they should fund with public money. Instead governments should take a mission-oriented approach to public investment, with a keen eye for what part of the innovation chain is insufficiently funded in a particular sector. The effectiveness of such a mission-oriented approach nevertheless "requires more capacity and understanding of the market than simply giving subsidies to every project or imposing an economy-wide standard" (Deleidi, Mazzucato, and Semieniuk 2020, 9).

Innovation missions could be seen as more than a financial instrument in the sense that they – if framed ambitiously – can crowd-in other forms of finance (Deleidi and Mazzucato 2019; 2021; Mazzucato 2019). In order to harvest this potential, it is key to understand that there are different levels of risk across the entire innovation chain. According to Mazzucato, one could talk about an eco-system of financing in which the public part in Europe consists of research funding, public venture capital funds, procurement instruments, national and regional public banks, and the European Investment Bank. If managed well the coordination of these financial instruments around missions could not only crowd-in private finance, but also mobilize crowdfunding and philanthropic funding along the full innovation chain (Mazzucato 2019).

Attempts to coordinate public sector funding bodies, however, has largely been ineffective in the UK in the 20th century development of biomedical research and exploitation by industry. Contrary to Mazzucato's argument, the lack of coordinated efforts has left room for different funders to pursue individual strategies and contribute to a diversity of funding approaches to the sector, which has proven to be a successful factor for British biomedical research and innovation (David C. Mowery, Nelson, and Martin 2010).

Investing in MOIP requires substantial financing. Drawing on empirical lessons from previous public research and development (R&D) programs Foray, Mowery, and Nelson point to the need for R&D programs to encourage diversity and competition when using technology policies to address grand societal challenges (D. Foray, Mowery, and Nelson 2012). Such challenges will involve many different technological

advances, and the most promising advances in such areas are highly uncertain. The importance of significant funding is reflected in the case of the substantial postwar US federal spending on defense-related R&D, whose sheer scale made it possible for the US to support competition within a diverse portfolio of technological alternatives that ultimately generated technological spinoff companies, supporting both innovation and the growth of high-technology industries in the US (D.C. Mowery 2012). However, sustaining a diverse and competitive base for R&D or production can be difficult or even impossible in extremely costly technologies (D.C. Mowery 2012).

Furthermore, fundamental change takes time. The history of energy technology innovation shows that the potential for accelerating innovation processes behind diffusion patterns through large investments in financial resources appears limited. The technological and institutional capacity for sustaining diffusion of energy technologies was typically built up over decades, and market-pull policies to support deployment and associated learning processes to reduce costs is likely to require long periods of large and sustained resource commitments (Grübler and Wilson 2013). A recent study found that it has taken from 20 to almost 70 years for a range of energy supply and energy end-use technologies to emerge from invention, diffuse into the market and reach widespread deployment (Gross et al. 2018).

It is relevant to keep in mind that the need for substantial, stable, and continuous funding to support direction in and maintain innovation efforts comes with possible trade-offs. First, as public budgets are not unlimited but often face constraints, public continuous funding for missions also requires flexibility within the overall mission to adapt to changing circumstances or new knowledge and consequently redirect funding efforts to where they are most effective. Second, in addition to tying funding to missions and ensuring directionality, governments also need private sector input to design public programs in order to ensure that technology development is connected to market needs (Anadon 2012). The second trade-off is related to the aforementioned risk of capture in section 2.1.4.

2.3 Governing missions

Most missions are defined, initiated and partly implemented by governments and public agencies and designed in a top-down manner, to some degree engaging industry and broader stakeholders in society (Joint Institute for Innovation Policy et al. 2018; Boon and Edler 2018). Initiators of missions are also found among large companies, foundations and private persons. However, present missions are by definition about setting directions of change by means of concrete and measurable targets often – but not exclusively – targeting societal challenges, which should be of primary concern to public organizations – the focus of this section.

A study prepared for the European Commission (Joint Institute for Innovation Policy et al. 2018) identifies four groups of governance and coordination of current (large) public MOIP initiatives: First, governance by *several ministries* subject to cross-governmental coordination include the US Cancer Moonshot, Japan's robotic technology strategy for elderly care, the Korean Brain Initiative, the Brazilian Inova Renewable Energy, and the German High-Tech Strategy (HTS). These initiatives have more complex governance structures to manage and coordinate cooperation between various public and private actors and across diverse political levels and jurisdictions – global, European, federal, state, and municipal – as well as interest groups, cooperatives, alliances, banks, and individuals. Second, governance and coordination by a *single ministry, agency, or local government body* include initiatives such as the National Program for Pain Management in Portugal, and the NEWater initiative in Singapore). Third, governance and coordination by *new mission-created governance bodies* such as the Delta Commissioner, which manages and

coordinates the Dutch Delta Plan, the Italian Committee for Policy, Coordination and Control project, which manages the project MOSE, the Swedish Climate Policy Council that assists the government by providing an independent assessment of how the overall policy presented by the government is compatible with the climate goals, and the Indian National Council for Electric Mobility (NCEM), which acts as the decision-making body for the National Electric Mobility Mission Plan 2020. Fourth, governance and coordination by a *public-private partnership* include the German Energiewende and the Chinese Deep-Sea Workstation. Generally, many stakeholders are actively involved in the initiatives mentioned in the report, although citizen involvement is almost non-existent with a few exceptions of city initiatives such as Clean Air London.

As previously mentioned, the nature of missions is both contested and negotiable, and MOIP can be understood as policy-led attempts to engage stakeholders around a particular goal (see section 1.2). In this sense, governing missions is a continual process of balancing centralized strategic decisions about goals and priorities with the need for engaging a wide range of decentralized public and private sector initiatives. This task is in contrast to the high degree of centralization characterizing governance in governments of EU member states today (European Commission 2017). Seeking such a balance consequently calls for not only new governance models, but also new capabilities in the public sector.

2.3.1 Capacities and capabilities of mission-oriented organizations

Besides funding, the success of missions depends on new organizational capacities and capabilities (Joint Institute for Innovation Policy et al. 2018). Institutions dedicated to running MOIP would have to engage in wide consultation with broader society as part of a discovery and learning process, since any organization has insufficient knowledge on how to obtain and plan for the success of missions addressing complex problems such as climate change and food security (Dominique Foray 2018). Mission-oriented organizations would have to engage in wide deliberation and negotiation with stakeholders and citizens in order to evaluate progress and secure democratic accountability in the evolution of open-ended missions (Kuhlmann and Rip 2018). Encouraging public and private stakeholders from various domains to take part in such missions will likely require new forms of collaboration beyond traditional policy practice (Janssen et al. 2020).

Kattel and Mazzucato diagnose modern innovation policy as being in a state of cognitive paralysis (Kattel and Mazzucato 2018). While wicked and complex societal problems are increasingly acknowledged by and put at the center of innovation policy, governments at the same time recognize the limits of existing policy implementation and the need for a more dynamic approach to pursuing missions. Kattel and Mazzucato call for more dynamic capabilities in the public sector based on the premise that wicked problems can only be solved through dynamic public-private partnerships. This involves capabilities for leadership and engagement by setting bold visions and directions for society and simultaneously encouraging bottom-up engagement from a wide set of social actors, embracing contestation and adaptability as conditions of societal mission.

Dynamic capabilities also entail the ability of the public sector to find coherent mixes of policy instruments and funding as well as an unprecedented ability to coordinate policy initiatives and efforts across policy levels, fields of ministerial responsibility, and social actors (Kattel and Mazzucato 2018). Dynamic capabilities include the willingness to experiment with the political toolbox as well as capabilities to evaluate whether or not such experiments make progress, require adaption or discontinuation. Finally, the authors argue, cross-departmental teams seem to be fundamental for managing missions. However, Kattel

and Mazzucato first and foremost point to the need for a better understanding of how the public sector can generate and sustain such dynamic capabilities.

The expert group on the Economic and Societal Impact of Research and Innovation (ESIR) of the European Commission highlights specific features and characteristics of more dynamic public sector organizations. These relevant institutions would have to: transform and create new markets and not just fix failures within existing markets; take charge of co-designing the mission implementation process as well as achievements of the mission; be accountable for the investments made; be adaptive to feedback from partners and operators as they progress and learn; be flexible in the uses of policy instruments; be able to co-design specific instruments if necessary; be able to cope with and adjust to existing operators in the innovation landscape; and not least be able to manage in a dynamic way the portfolio of projects and programs supporting the missions in order to re-orient research and funding according to emerging opportunities (European Commission 2017).

2.3.2 Coordinating missions

Coordinating missions for wicked problems across various policy fields has in itself been referred to as "perhaps the most "wicked" issue in policymaking" (Kattel and Mazzucato 2018, 790), a challenge often impeding transitions, possibly including the goals of missions for example (Janssen et al. 2020). Still, most of the literature on MOIP settles for claiming the need for better coordination and offers little insight into the challenges and intricacies of coordination efforts in modern policymaking.

Coordination is not just a strategic planning exercise, but an ongoing process of making way by means of deliberation, negotiation and learning through new and uncertain territory. Missions attempt to address what Weber and Rohracher named policy coordination failure (2012). This failure can be attributed to a lack of *multi-level policy coordination* across different systemic levels (e.g. regional–national–European or between technological and sectoral systems); a lack of *horizontal coordination* between research, technology and innovation policy, sectoral policies (e.g. transport, energy, health, industrial sector policies), and cross-cutting policies (e.g. tax policy, economic policy, regional policy); and a lack of *vertical policy coordination* between ministries and implementing agencies. Missions extend beyond the innovation system mobilized for pursuing the mission and into the broader socio-economic system affected by the challenge targeted by the mission (Janssen et al. 2020). In this sense, missions represent the anything but straightforward challenge of coordinating MOIP initiatives with not only the many other political priorities of a government across its many political and organizational levels and complex responsibilities, but also with markets and/or civil society at large. Setting the direction for innovation governance through missions is a matter of negotiating with path-dependent structures of prior experience in current political institutions and decisions as well as the myriad of political interests and considerations, all of which constitute a society.

MOIP is argued to be domain specific – not to be confused with sector specific – focusing on food or energy challenges for example, and consequently political targets should be set in those domains (Joint Institute for Innovation Policy et al. 2018). Innovation policy should not be seen in isolation and should be more concerned with impact and how innovation outcomes are scaled, diffused, and generalized within said domains. This implies more proactive monitoring, coordination and alignment of innovation policy and sectoral and thematic policies. As a consequence, governing MOIP involves broader involvement of private and third sector stakeholders (Wanzenböck et al. 2020). MOIP, in other words, must coordinate

the traditionally sector-neutral policies fixing generic market failures with non-neutral actions targeting investments and resources in specific sectors or technologies (Dominique Foray 2019).

Breaking or eliminating silos between sectors and disciplines is a recurrent claim of successful missions in much of the literature (Joint Institute for Innovation Policy et al. 2018; Sorokins, Griniece, and Dudek 2018; The Joint Institute for Innovation Policy et al. 2018). As Mazzucato puts it: "[m]issions aimed at creating and shaping markets are by definition cross-sectoral and should span across multiple public organisations" (ministries, departments, national and local level governance) (Mazzucato 2019, 12). Such elaborate coordination could be argued to reflect a different management doctrine than the new public management, whose management focus on individual programs and decentralization since the 1980s has made policy coordination one of the most widespread challenges for governments today (OECD 2019).

2.3.2.1 Attempts to coordinate complex and crosscutting initiatives often fail

Outside the topic of MOIP a rather extensive academic literature – which is just touched upon briefly here – is engaged with the potentials for and limitations of coordination and integration of public policies (Trein, Meyer, and Maggetti 2019; Molenveld et al. 2020). Whereas integration is used to describe incorporation of policy goals and instruments into a larger entity such as a public organization for example, coordination refers to the reorganization of typically administrative units.

The literature indicates that individual organizations tend to perceive crosscutting policy programs as claims for scarce resources, and that crosscutting problems and subsequent programs – which missions are by definition – are more complex and have a higher risk of failure than those confined to single sectors or organizations (Molenveld, Verhoest, and Wynen 2020). Managing such risk is not just a matter of enforcing strong hierarchies and centralized top-down management, but also about having a flexible approach to coordination opening up to local differentiation, increased incentives, and a collaboration-oriented culture (Molenveld et al. 2020).

Existing experiences with integrated policy strategies – a particularly ambitious form of policy integration prescribing concerted policy-making efforts across sectors – for tackling issues of decreasing food security and climate change for example are almost exclusively reports of failure (Candel 2017). Although findings are not conclusive, they do give rise to serious consideration of the scope of the challenge governments are facing when pursuing MOIP. Furthermore, the findings also raise a concern with the degree of coordination desired for MOIP.

Coordination is not always the answer, and too much of it can be a problem as pointed out by B. Guy Peters, an influential scholar on public policy and administration. First, it can undermine the potential benefits achieved through specialization, such as specific ministries with expert knowledge on specific problems. Second, too much coordination can challenge the degree of freedom that innovation tends to require, but which tends to have difficult conditions, when governments are too set on managing and coordinating scientific efforts according to a more linear perception of the path to innovation. Third, it can compromise the competition necessary for developing the best technological solutions to social problems. Fourth, just as coordinated public services and information collection can help protect individual rights in criminal investigation, social and health programs for example, too much coordination of information collection about citizens may also pose a threat to civil liberties. Fifth, not only hierarchical control over but also competition between public organizations can function as a means to seek accountability and better social services [e.g. in research and innovation funding], and blending resources from

different sources and legal authorities can challenge the capacity for monitoring performance and seeking accountability (Peters 2018).

2.3.3 Research portfolio management

Missions require a diverse portfolio of projects to encourage a multitude of bottom up solutions (Mazzucato 2018b; 2019). Funding for such a portfolio should stimulate interaction, experimentation and cross-learning, with a continuous effort to evaluate the contribution from individual projects to the mission objective and redirect funding to other activities if necessary. In this sense, the portfolio approach is an argument for more proactive and flexible management of funded projects, in which the managing organization relies heavily on strong in-house capabilities to balance the risk of wasting resources on futile projects with the risk of writing off their unexpected value (Mazzucato 2018a). The idea of balanced proactive management of public funding, which actively decides upon the promising nature of funded projects, can be argued to be antagonistic, running the risk of increasing bureaucracy in the funding organization at the expense of creating space for experimentation in the projects funded (Sorokins, Griniece, and Dudek 2018).

Portfolio management in science policy remains a vague albeit central concept to the literature on mission-driven innovation policy. The term "research portfolio" in all simplicity often refers to a collection of projects with a common goal supported by a public research funding agency for example. While straightforward, this definition provides little assistance in explaining, how such a portfolio could be evaluated and managed, let alone which capabilities are central to more proactive portfolio management.

Box 3 Portfolio based innovation policy

According to Grübler and Wilson (2013), venture capitalists build energy technology portfolios with an expected 90 percent failure rate, knowing that the 10 percent that break through will support returns for the portfolio as a whole. Given the unpredictable and uncertain outcomes of developing new technologies, such an expectedly high failure rate underlines the crucial point of diversifying public investments in a wide range of research projects rather than picking winners.

However, while portfolio based innovation policy should be concerned with maintaining diversity of technologies, such policy should also be concerned with the conflicting aim of "improving economics through standardisation, scale, and concentration" of a few strategic technologies, as portfolios will inevitably be resource constrained (Grübler and Wilson 2013, 381). According to the authors, diversified portfolio management is likely to be more feasible when dealing with less capital-intensive technologies, while single, "lumpy", large-scale investments in technologies at scale such as energy supply technologies run the risk of exposing portfolios to the risk of failure.

The term "research portfolio" originates from private sector research management as an analytical tool aimed at mitigating risk and maximizing return on investment from corporate R&D (Wallace and Rafols 2015). Borrowing this term from the private sector, an actual definition on a public research portfolio and how it can be analyzed is still absent, and the public use of the term is merely associated with the corporate idea of managing and prioritizing multiple projects according to risk-analysis and alignment with the goals of the company. On a broad level, this association is useful as a reminder of the risk related to investing in firms and technologies, where the potential impact of technologies is unpredictable and where some inevitably will fail. Seen through the lens of corporate portfolio management, more successful

projects will help cover the losses of public investment from others (Mazzucato, Kattel, and Ryan-Collins 2020).

Nevertheless, public sector institutions such as research funding agencies are not tasked with maximizing monetary returns but with pursuing a range of "public good" outcomes (Wallace and Rafols 2015). The public sector has an additional layer of considerations. As Rodrik points out: "if green technologies both produce technological externalities and help counteract the underpricing of carbon [...], commercial profitability or breaking even is not the appropriate benchmark for success" (Rodrik 2014, 480).

In certain ways, the rationale guiding portfolio management in the public sector fundamentally differs from the private sector. Priority-setting of public value is essentially political and identifying criteria for success and failure that are democratically legitimate involves some degree of societal deliberation in order to reach a compromise between divergent views and interests. Furthermore, risk associated with investing in the public good is related to uncertainty of both the potential outcome of research projects and the likelihood of achieving such an outcome, leaving the research funding agency with "highly incomplete knowledge, close to ignorance" (Wallace and Rafols 2015, 103).

Box 4 International lessons with active portfolio management

For decades, the American agencies for the development of new technology within defense and energy – Defense Advanced Research Projects Agency (DARPA) and Advanced Research Projects Agency-Energy (ARPA-E) – have quite successfully worked with active portfolio management of their investments in challenge- and thematic-driven programs with the purpose of developing groundbreaking new technologies.

Building on the lessons from these agencies as well as other international practices, Frølund et al. define active portfolio management as a decisive way to increase the probability of success of a portfolio of high-risk projects within a program towards a desirable impact of the program (2020). Frølund et al. argue that such portfolio management can be implemented in the European Innovation Council (EIC). It will, however, require sufficient resources allocated to the programs of the EIC in order for them their stated goals. It will require the recruitment of highly competent managers who are visionary, technologically strong, mission-driven, highly motivated and adaptive, supported by a competent team with expertise on the market and networks to engage key innovation ecosystems.

The program manager should not only be visionary but also responsive to the insights into technological opportunities of Europe's innovation ecosystems. An active portfolio management places great demands on the ability of the program manager to be in widespread contact with relevant ecosystems and, on the basis of an ongoing dialogue with said ecosystems, independently manage to set a direction for the program. This involves the ability of the program manager to initiate partnerships with researchers and companies that do not automatically seek collaboration but nevertheless have the potential to advance the objectives of the program. The strategy for the optimal portfolio of supported projects must focus on which types of partnerships, the specific program must support, what kind of funding is needed, and whether the program manager should address other factors such as regulatory challenges standing in the way of the diffusion of the new technologies (Frølund et al. 2020).

The use of experts' advice including facilitated meetings between R&D and commercialization experts seems an inevitable part of the assessment process necessary for a continuous evaluation of a

technology research and evaluation portfolio. Pugh et al. (2011) deem subjective assessment critical when evaluating the likelihood of the success of achieving advanced technology goals. The authors present two analytical methodologies for performing more stylized climate change portfolio analyses, given the conditions of limited budgets, often limited time for analysis, and institutional constraints regarding important issues such as expert uncertainty analysis present in public R&D funding organizations. Both methodologies rely extensively on subjective probability assessments and expert elicitation.

Beyond a project-based approach, the term portfolio analysis sometimes refers to a portfolio of instruments, policies, and interventions (Mazzucato, Kattel, and Ryan-Collins 2020; Hille, Althammer, and Diederich 2020; Aalbers, Shestalova, and Kocsis 2013). This perspective resembles the somewhat related literature on innovation policy mix, which has gained traction in the last decade and will be further explored in section 2.3.4.

2.3.4 Using a mix of policy instruments

Setting the direction for MOIP is not only a matter of supporting research and technology development projects. Successful innovation depends on several complementary factors beyond knowledge interaction between universities and private or public organizations These include skills to absorb new knowledge and adopt new technologies in public as well as private organizations, demand for innovative solutions in order for them to be diffused and adopted in society, finance for the development and diffusion of innovation, and institutions shaping the possibility for the development and diffusion of innovation by means of regulation as well as informal norms and rules (Fagerberg 2018). As for the latter, this is a matter of adjusting incentives by on the one hand supporting radically new technical solutions unable to compete at first with existing products and services which have enjoyed decades of stepwise improvements, and on the other hand penalizing the use of problematic[1] existing products and services (Janssen et al. 2020).

The interest in how complementary instruments can support the direction of missions is closely related to the literature on policy mixes, a concept which has particularly gained ground in academia the past decade. Central to the idea of an innovation policy mix is the argument that policy instruments do not work in isolation, and consequently that the contribution from one political instrument to a desired policy outcome should be analyzed, evaluated and understood in terms of the contribution it makes to an existing group of instruments (Kern, Rogge, and Howlett 2019). This is not an unproblematic task of optimizing effective or balanced policy mixes through systemic coordination of public policies, which is somewhat impracticable as policy mixes are highly complex, cover various political rationales, and typically result from incremental changes, introducing modifications to existing instruments or adding new ones to the mix (Magro and Wilson 2019). Rather, the concept is a useful reminder of having to reflect on the rationales of each instrument and the trade-offs between different policies and the way they impact the goals of innovation policy (Flanagan, Uyarra, and Laranja 2011).

[1] Despite a general political perception of innovation – which has without doubt contributed to significant social and economic progress – as something inherently good for society, there is also a dark side to innovation with potential harmful aspects such as the public health risks of tobacco, the environmental degradation caused by human progress, the erosion of privacy due to excessive monitoring, the threat to democracy from fake news, etc. (Coad et al. 2020).

MOIP covers *financial instruments* (e.g. R&D and innovation subsidies or grants, funding of infrastructures), *regulatory instruments* (e.g. State Aid rules, industry standards), and *soft instruments* (e.g. articulation and communication of visions, seeking democratic legitimacy through engagement of stakeholders and civil society) (Boon and Edler 2018; Dominique Foray 2019; Mazzucato 2019; Borrás and Edler 2020).

Overall, instruments can be divided into demand-side and supply-side instruments. Supply-side policy instruments focus on supporting firms and research organizations in generating new knowledge that may eventually lead to new products and services (science, technologies, human capital, R&D). Demand-side policy instruments focus on stimulating the demand for innovative products, thus providing incentives for firms to innovate (procurement, adoption, prices and tax) (OECD 2011).

Most of the literature on MOIP does not distinguish between mission-oriented and other instruments. The OECD chooses to define mission-oriented instruments as instruments with a certain degree of strategic orientation, thereby ruling out indirect support measures (such as tax credits), purely bottom-up initiatives such as investigator-led research schemes or open innovation support measures such as vouchers as well as initiatives relying on single instruments with no specific coordination with specific political priorities (OECD 2019). Others argue that sector-neutral or horizontal policies focusing on skills, infrastructure, and education are insufficient when facing grand challenges such as climate change and should be complemented with vertical instruments aimed at innovation in certain fields and/or domains and consequently engage with specific problems for a specific technology or sector (Dominique Foray 2019; Mazzucato, Kattel, and Ryan-Collins 2020). Frenken argues that sector neutral policies such as generic R&D subsidies will benefit large incumbent firms – primarily within manufacturing as opposed to service sectors – that generally have more R&D activity, more resources for engaging in research and innovation activities on their own and with relevant partners within the innovation system (Frenken 2017). According to the author, more specific policies are needed in order to address the most pressing societal challenges and support the future markets for technologies that do not yet exist. However, this does not mean that more sector-neutral, horizontal and/or single policy instruments cannot be relevant to societal challenges or missions – they are just not adequate tools when used for direction setting (Dominique Foray 2019; OECD 2019; Mazzucato, Kattel, and Ryan-Collins 2020). It should be noted that missions are essentially strategies for aligning and adapting policy instruments, many of which are likely to be existing ones.

2.3.4.1 Innovation policy for grand challenges: lessons from different sectors

How can innovation policy pursue targets of missions addressing the problem of grand challenges? This question is pertinent to part of the literature, which seeks to draw on lessons from historic mission-oriented R&D programs for different sectors in formulating ways for innovation policy to contribute to a green transition of society.

Overall, history points to seven general and complementary lessons for directing innovation policy towards major societal challenges (D. Foray, Mowery, and Nelson 2012; David C. Mowery, Nelson, and Martin 2010). First, R&D programs must support development and deployment of many different technologies, as complex challenges such as climate change will not be overcome by a single solution. Second, public programs should focus on long-term support for developing and improving relevant technologies rather than supporting one-time technological breakthroughs. This includes both basic and applied research as well as development activities. Third, public procurement and regulatory policies can be used for promoting certain technologies or solutions, as successful mission-oriented R&D programs have

often benefitted from strong demand for the technologies developed. Fourth, public programs should be designed to support and encourage broad dissemination of scientific and technological knowledge stemming from public investment in order for such knowledge to have wider influence on innovation as well as to avoid monopoly positions in relevant technological fields. Fifth, it is important that the funding for as well as priorities of a mission are stable and credible. Sixth, international cooperation is an important element of R&D programs seeking new solutions to complex challenges. Seventh, missions addressing global challenges should aim to deploy technological solutions on a global scale as soon as possible.

Following substantial investment which missions require (see section 2.2), Foray, Mowery, and Nelson argue that public R&D programs should invest public money where "the value to society of the expected returns to R&D is high but private firms' willingness to invest at that stage is low"(D. Foray, Mowery, and Nelson 2012, 1700). Furthermore, they underline the importance of public money supporting and encouraging broad dissemination of scientific and technological knowledge, which the public funds. This should bolster the dissemination of results to all relevant fields and potential users and act as a way to avoid private companies using public money for establishing monopoly positions in vital technological fields (D. Foray, Mowery, and Nelson 2012). In terms of dissemination of knowledge, funding university researchers rather than other research institutions has the benefit of dissemination through the potential close interaction between research and training (David C. Mowery, Nelson, and Martin 2010).

It is important, however, to recognize that there is no one-size-fits-all innovation policy (Brown 2020). The context for mission-oriented R&D initiatives differ across sectors. Defense-related R&D programs in the 20th century were characterized by governments as the primary customer adopting new technologies, and public procurement is traditionally less common in other fields, which in turn should be more concerned with supporting technology adoption (D.C. Mowery 2012). In line with this point, demand for and adoption of new technologies has been key to the success of the 20th century agricultural research missions in the US, Mexico and the Rockefeller Foundation (Wright 2012). As for cleantech, it is unlikely that public clean R&D support programs will prove effective if they are not complemented by high carbon prices obtained through a carbon tax or a cap-and-trade-system, which will increase incentives for the private sector to develop new clean technologies and accelerate the adoption of existing cleaner technologies (Veugelers 2012; Grübler and Wilson 2013). Rapid diffusion of renewable energy technologies is crucial, if countries are to meet their respective climate targets (van der Loos, Negro, and Hekkert 2020).

2.3.5 Evaluating missions

As much of the literature on MOIP is conceptually oriented and empirically ill-supported, a great deal is said about how missions *should* be evaluated and little about whether and how such evaluation *can* actually be undertaken. There is currently no systematic overview of 'good practices' of assessing and evaluating mission-oriented programs available yet (The Joint Institute for Innovation Policy et al. 2018).

Conceptually missions require dynamic metrics and evaluation (European Commission 2017) allowing for initiatives to be reassessed, potentially adapted to new developments, or possibly stopped (Joint Institute for Innovation Policy et al. 2018). Rather than justifying public interventions, evaluation should be considered as a tool for constant learning and adaptation as projects and programs progress – even if they fail (Amanatidou et al. 2014; Grillitsch et al. 2019; Mazzucato, Kattel, and Ryan-Collins 2020; Kattel and Mazzucato 2018). Such evaluation of transformative innovation policy could be argued to be formative,

“aiming to improve the definition and implementation of the interventions under evaluation and involving the policy participants“ (Molas-Gallart et al. 2020).

Evaluation of missions should begin go beyond traditional cost-benefit analyses and seek a wider understanding of the value public policies can create, including potential spill-over effects that can be directly attributed to mission implementation (Mazzucato 2019). Mazzucato argues that the Apollo Moon landings would not likely have seen the day if they had been evaluated based on a cost-benefit analysis. Such cost-benefit analysis would have overlooked the many technological spin-offs and spillovers that were the main social and economic benefits of the Moonshot mission, just as cost-benefit analyses would deem the Concorde plane an utter failure without acknowledging the cross-sectoral investments and innovations it also induced. As Mowery stress: “the ultimate “output” of defense-related R&D is a quintessentially public good, national security. The economic value of “national security” cannot be measured effectively, meaning that the direct value of the results of defense-related R&D cannot be captured by conventional economic measures” (2012)

Evaluation should be concerned with portfolios rather than simple projects or instruments (The Joint Institute for Innovation Policy et al. 2018), and evaluation should be continuous and dynamic throughout the innovation policy process (Mazzucato and Semieniuk 2017). A precondition for evaluation of missions is defining concrete targets and objectives, making it possible to say whether policies have been achieved or not (Mazzucato 2018a). Such targets and objectives allow for monitoring developments, but it might be hard to attribute these developments to precisely the influence of MOIP, as MOIP typically builds on coordination activities and alignment of a broad range of existing and new policies, together improving the conditions that might contribute to the development and applications of innovative solutions. Finally, it must be taken into consideration that modern grand challenges are more long term and more difficult to evaluate than more technological missions of the past (Mazzucato, Kattel, and Ryan-Collins 2020). To the extent that MOIP relies on instruments or projects with clear boundaries, it may still benefit from more traditional evaluations.

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