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Public participation in mission-oriented innovation projects

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ABSTRACT

Mission-oriented innovation policy is currently gaining renewed interest as an approach for addressing societal challenges. One of the promises is that missions can mobilise and align diverse stakeholders around a shared goal. Recent literature underlines the importance of public participation (e.g. municipalities and civil society organisations) in the socioeconomic transformations required for attaining missions. We ask how public participation differs among (non-)mission-oriented innovation projects. Drawing on a database containing Dutch government-funded innovation projects, we investigate whether mission-oriented projects are associated with *earlier*, *more open*, and *more influential* forms of public participation than conventional projects. Although the results suggest that mission-oriented projects indeed correspond with earlier participation of more public actors, we find little evidence that they also coincide with increased diversity and financial influence of public participants. We conclude by discussing how policymakers and intermediaries may engage in strategies to make missions more inclusive.

1. Introduction

Research and innovation (R&I) can play a major role in addressing societal challenges such as climate change, pandemics, and security (European Commission, 2009). *Mission-oriented innovation policy* (MIP) is devoted to directing R&I to such challenges (Ergas, 1987; European Commission, 2018). A classic example is the ‘man-on-the-moon’ program (Nelson, 1974). Many contemporary challenges are nevertheless acknowledged to be *wicked*, meaning that they are associated with complexity, uncertainty, and contestation (Head, 2008; Rittel and Webber, 1973). They require insights and coordination among numerous actors to support system-wide sociotechnical transformations (Diercks et al., 2019; Kuhlmann and Rip, 2018; Schot and Steinmueller, 2018). In contrast to the traditional technology-focused notion of missions, increasingly more MIPs are associated with “an urgent strategic goal that requires transformative systems change directed towards overcoming a wicked societal problem” (Hekkert et al., 2020, p. 76). These MIPs are believed to be coordination mechanisms for aligning and mobilising heterogenous stakeholders around a shared goal (Janssen et al., 2021).

Driving system-wide transformation requires cooperation between various stakeholders (Linder et al., 2016; Loorbach and Rotmans, 2010; Mazzucato, 2016, 2017; Rabadjieva and Terstriep, 2021; Wanzenböck et al., 2020). While research has focused on the private sector's participation in MIP (Kattel and Mazzucato, 2018; Mazzucato and Robinson, 2018), little research has focused on public participation (Diercks et al., 2019; Janssen et al., 2021; Köhler et al., 2019). The involvement of public actors – here understood as non-conventional innovators like citizens (Schot et al., 2016), cities (Bulkeley and Casta, 2013), and NGOs (Kuhlmann and Rip, 2014) – is nevertheless crucial for the success of R&I processes in driving transformation (Haddad et al., 2022; Wanzenböck and Frenken, 2020; Weber and Rohracher, 2012) and in generating socially desirable outcomes (Stilgoe et al., 2013; Von Schomberg, 2013). If mobilising actors into a uniform direction is the aim of missions, then it is essential to understand how the participation of public actors takes place (Janssen et al., 2023).

However, there is a considerable gap between the literature on MIP and on public participation in R&I (Shanley et al., 2022). It remains unclear to what extent a mission orientation encourages the involvement of publics. It is not known how public participation differs between mission-oriented and non-mission-oriented projects, and how missions differ among each other in this regard.

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This study addresses these knowledge gaps and contributes to MIP theory and practice by quantitatively testing whether mission-oriented projects meet the normative aspirations of facilitating more effective public participation than conventional projects. By doing so, we gain insights into the participatory performance of mission-oriented projects. We identify characteristics that affect this performance, provide valuable policy recommendations, and specify promising future research avenues related to public participation and MIP.

The paper is structured as follows. Section 2 discusses a mission's main rationales for public participation. This study then follows Rowe and Frewer (2004)'s suggestion to first define *effectiveness* of participation, which allows us to develop hypotheses in preparation for our analysis. Section 3 subsequently proposes an *operationalisation* of the respective effectiveness aspects as input for our *assessment* of missions-oriented projects. Section 4 then presents the results which are further dissected and discussed in Section 5.

2. Theory

2.1. Missions and public participation

MIP stems from the notion that patterns of R&I are accumulative and that sociotechnical change is characterised by a rate and direction (Dosi, 1982; Kuhn, 1962). While change can be divergent (i.e. creative destruction) or convergent (i.e. creative accumulation; Schumpeter, 1934), MIP may guide these Schumpeterian waves through the selection of priority themes (Foray, 2018). Despite the fact that governments have deployed such 'selective' or 'preferential' national innovation policies for nearly a century (Cantner and Pyka, 2001; Chavez et al., 2017; Ergas, 1987; Roth et al., 2021), scholars argue that a renewed interest in MIP has emerged due to its potential for uniting actors around clearly defined goals in order to tackle wicked societal challenges (Janssen et al., 2021; Mazzucato, 2018a; Wanzenböck et al., 2020). Contemporary MIPs are frequently classified as 'normative' or 'third generation' innovation policies targeted at driving sociotechnical transformations (Schot and Steinmueller, 2018).

One target audience for these policies, as with earlier generations of innovation policies, are firms. Providing direction and perspective helps them to deal with the uncertainty and turbulence associated with impending transformations (Linton and Walsh, 2004). It encourages firms to assess which of their core competencies match emerging markets, and which of these are needed to develop a (sustainable) competitive advantage (Barney, 1991; Marino, 1996; Prahalad and Hamel, 1994). Such core competencies allow firms to "adapt quickly to changing opportunities" (Prahalad and Hamel, 1990, p. 4).

Apart from mobilising firms, attaining missions and driving transformations also requires participation from a broader set of stakeholders (Borrás and Edler, 2014; Diercks et al., 2019; Edler and Fagerberg, 2017; Kuhlmann and Rip, 2018; Schot and Steinmueller, 2018), including public actors (Bugge and Fevolden, 2019; Mazzucato, 2018a, 2018b; Surie, 2017). More specifically, various normative, instrumental, and substantive arguments in favour of public participation (Stirling, 2008) resonate with MIP.

Western scholars frequently adopt an oversimplified logic: "the technical is political, the political should be democratic, and the democratic should be participatory" (Moore, 2010, p. 793). Benefits associated with public participation include the opportunity for local publics to express, exchange, and act upon their values and worldviews (Bauer et al., 2021; Steen and Nauta, 2020; Sykes and Macnaghten, 2013). As a result, participation is arguably the right thing to do from a normative democratic perspective (Stirling, 2008).

Considering that missions are geared towards driving transformative change, instrumental and substantive arguments in favour of public participation can be made in relation to preventing and overcoming transformational system failures (Weber and Rohracher, 2012). For instance, public actors contribute to the social construction of technologies (Bijker, 1995; Pinch and Bijker, 1984), and thus influence how mission-oriented innovations are perceived and embedded in society. The literature on public participation assumes that the values and worldviews that guide R&I, and which affect their social construction, cannot be determined top-down or *a priori* but should be explored in inclusive deliberations with diverse societal stakeholders (Bauer et al., 2021; Genus and Coles, 2005). By means of co-production, the public's involvement can help mitigate demand articulation failures (Fisher et al., 2018; Surie, 2017), reflexivity failures (Garud and Gehman, 2012; Smith et al., 2014), and directionality failures (Grillitsch et al., 2019; Janssen et al., 2021; Sykes and Macnaghten, 2013).Missions are hoped to empower public actors to participate and contribute to mission-oriented R&I. Although current literature pays ample attention to *creating* new missions, it tends to neglect the *process* of achieving them. In order to better understand the dynamics and governance of missions, research needs to investigate to what extent missions mobilise and empower the public (Janssen et al., 2021).

While many scholars acknowledge the importance of including 'the public', the notion of the public itself is controversial and has different meanings in different academic disciplines (Pesch et al., 2020). Science & Technology Studies tends to refer to citizens and civil society organisations; Innovation Management frequently gravitates towards users and consumers; while Innovation Studies tends to include cities and governmental bodies. In this paper, our working definition for the umbrella term 'the public' refers to all these actors above and hence excludes conventional innovators, i.e., industry (e.g. incumbents and SMEs) and knowledge institutes (e.g. universities and research institutes).

Public participation is broadly described as an inclusive process that allows (potentially) affected actors to partake in the decision-making process of R&I (Newig and Kvarda, 2012; Rowe and Frewer, 2000; Smith, 1983). Although there are many forms of participation (Lynam et al., 2007; Reed et al., 2009; Rowe and Frewer, 2000, 2005), this paper focuses on forms that Arnstein (1969) labels as 'higher degrees of power'. As such, we understand public participation as public actors formally partaking in R&I projects by either having full control, delegated power, or influence through partnerships. The imperative of public participation in mission-oriented R&I raises the question to what extent missions encourage public participation and how this can be measured.

2.2. Measuring public participation

2.2.1. The challenges of measurement

Measuring public participation is challenging. Public participation is complex and contested in itself. There is no consensus on what evaluation criteria to use, no dominant evaluation method has emerged, and few reliable tools for measurement exist (Rosener, 1981; Rowe and Frewer, 2004). As a result, analyses are often context-dependent and rely on practicalities such as data availability. To deal with this, Rowe and Frewer (2004) propose to first define public participation's 'effectiveness' (1), to operationalize it accordingly (2), and to subsequently conduct the evaluation and interpretation (3). We adopt three dimensions inspired by Callon et al. (2009) that characterize the participation's effectiveness, and which have gained popularity in the academic discourse over the last decade. An advantage of these dimensions is that they particularly focus on the process of public participation rather than its creation or outcomes. These respective process dimensions are referred to as *intensity*, *openness,* and *quality*.

2.2.2. Intensity

The intensity of public participation refers to "how early laypersons are involved in research [and innovation]" (Callon et al., 2009, p. 158). Although innovation is a complex and iterative process containing feedback loops (Kline and Rosenberg, 1986), many simplistic and disputed linear models have emerged in the literature. These roughly share the proposition that R&I processes can be conceptualised into the following phases: basic research, applied research, invention, development, production, and diffusion (Godin, 2005; Godin and Lane, 2013). Early participation refers to the upstream stages of basic and applied research (Delgado et al., 2011; Wilsdon and Willis, 2004).

MIP frequently draws on novel, contentious scientific research in an early stage, to frame complex societal problems and envision potential resolutions (Schot and Steinmueller, 2018). Such scientific knowledge is often associated with many uncertainties, ambiguities, and unknowns (Stirling, 2010). Scholars therefore advocate upstream public participation to collectively confront the inherently imperfect foresight of experts and decision-makers, and to complement this with the public's knowledge, skills, and values (Jasanoff, 2003). As such, upstream participation can help MIP to deal with the Collingridge dilemma (Collingridge, 1980) – a lack of knowledge on how to govern, direct, and shape technologies before path dependencies (David, 1994, 1995), technological lock-ins (Arthur, 1989), and entrenchment occur (Collingridge, 1980). Public participation could therefore enable mission-oriented innovators to proactively respond to early concerns, values, needs, and expectations of the public before this becomes problematic (Genus and Coles, 2005; Stilgoe et al., 2013). A vivid example is the climate geoengineering SPICE project that showed that the expression of societal concerns in early participation can lead to more anticipatory and reflexive research practices (Pidgeon et al., 2013; Stilgoe et al., 2013). As a result, many scholars have advocated for high intensity public participation (e.g., Chess and Purcell, 1999; Kearnes et al., 2006; Mazmanian and Nienaber, 1980; Reed, 2008; Rowe and Frewer, 2000).

On this account, early participation is considered favourable or even the norm for projects that induce transformative change. One might therefore expect that mission-oriented projects are characterised by earlier participation than non-mission-oriented projects. As a result, this paper aims to test this by hypothesizing the following:

Hypothesis 1. *Mission-oriented projects exhibit public participation in an earlier phase than non-mission-oriented projects.*

2.2.3. Openness

Openness refers to the ease of partaking in the R&I process and can be measured by the number and diversity of public groups participating (Callon et al., 2009). The vast literature on open innovation has demonstrated that there is much to gain from involving different types of actors in R&I processes (Huizingh, 2011; van de Vrande et al., 2009; West and Bogers, 2014). Successful innovations need diverse stakeholder participation to obtain a broad range of values and worldviews that reflect those of society (Bugge and Fevolden, 2019; Diercks et al., 2019; Schot and Steinmueller, 2018).

Mission-oriented projects that drive transformative change can face contestation if they lack the necessary legitimacy (Edler and Boon, 2018; Wanzenböck et al., 2020). Openness can provide this legitimacy, as diversity is essential for attaining moral legitimacy (Suchman, 1995), input legitimacy (Scharpf, 1997, 1999), and throughput legitimacy (Schmidt, 2013). Diverse input can also lead to better decision-making (Beierle, 2002; Koontz and Thomas, 2006; Newig, 2007; Newig and Fritsch, 2009; Reed, 2008; Stahl, 2013; Stirling, 2010), hence providing output legitimacy (Scharpf, 1997, 1999).

Open participation is essential for mission-oriented projects as it can bring to light a variety of concerns (Latour, 2004) and emotions (Roeser, 2012) and therefore reveal possible value conflicts (Smith, 2003). By extension, innovators can better understand the meaning of social desirability (Owen et al., 2012) and align their role-specific activities with their societal duties (Grinbaum and Groves, 2013).

Addressing societal challenges requires open reflexive processes in which diverse actors challenge the purpose, process, and (long-term) implications of R&I in light of uncertainty and complexity (Ferraro et al., 2015; Schot and Steinmueller, 2018; Stilgoe et al., 2013; Weber and Rohracher, 2012). Consequently, openness is necessary to identify risks (Sykes and Macnaghten, 2013; Van den Hoven et al., 2013) and opportunities (Fraaije and Flipse, 2020; Sutcliffe, 2011), and to stimulate so-called 'deep learning'. Outside perspectives can enhance the reflective and anticipatory capacity of innovation processes (Fraaije and Flipse, 2020; Stilgoe et al., 2013) and therefore aid in overcoming reflexivity and demand articulation failures (Weber and Rohracher, 2012).

Based on MIP's rationales for openness, one might expect that these projects are open to a higher number, and a more diverse group, of public participants than non-mission-oriented projects. We test this by hypothesizing the following:

Hypothesis 2a. *Mission-oriented projects have a higher number of public participants than non-mission-oriented projects.*

Hypothesis 2b. *Mission-oriented projects have more diverse public participants than non-mission-oriented projects.*

2.2.4. Quality

Quality refers to the gravity of participation and the extent to which the public can push their ideas into innovation (Callon et al., 2009). It directly relates to the public's influence on decision-making (Fiorino, 1990; Reed, 2008) in mission-oriented projects. Influence contributes to the public's ability to shape technological developments and largely stems from their available resources (Rowe and Frewer, 2000). Wanzenböck and Frenken (2020) hint that missions require a decentralised empowerment of local stakeholders to better understand the contextual manifestations of challenges and better develop the contextual resolutions for these. Although bottom-up innovators tend to understand the local needs, perspectives, and values better, they often lack the resources to sustain or fully meet these demands (Hossain, 2016; Seyfang and Smith, 2007). Providing the public with resources hence appears an important requisite for achieving missions. If enabled, the public could even develop resolutions on their own as user innovators (von Hippel, 1988, 2005) as opposed to being co-creators in processes of open (Chesbrough, 2003), open-source (Raymond, 1999), and participatory innovation (Buur and Matthews, 2008). Still, it is essential to consider the public's influence in light of other decision-makers, as inequality is a strong barrier to participation (Reed, 2008).

Due to the importance of the public's ability to redirect and shape R&I based on their values and experience vis-a-vis societal challenges, one might expect that the public has a more influential presence in mission-oriented projects than in non-mission-oriented projects. Assuming that influence in such projects is related to the volume of resources that participants commit (Rowe and Frewer, 2000), we hypothesize the following:

Hypothesis 3. *In mission-oriented projects public participants have more influence than in non-mission oriented innovation projects.*

3. Method

3.1. Research design & case description

This cross-sectional research aims to understand to what extent a project's mission orientation is associated with more effective forms of public participation (i.e., intensity, openness, and quality) compared to projects without a mission orientation.

We selected the project administration of the Dutch Public-Private Partnership Allowance (PPP-Allowance)[1] as our empirical basis. This policy instrument supports public-private innovation projects by offering an allowance based on 30% (previously 25%) of private investments made in earlier public-private innovation projects. An important requirement is that both the allowance-generating and the allowance-

[1] In Dutch: Publiek-Private Samenwerking toeslag (PPS-toeslag)

using projects should fit the scope of the Knowledge and Innovation Agendas (KIAs) that form part of the Dutch national innovation strategy. This strategy originally consisted of the Topsector policy, launched in 2012 by the Ministry of Economic Affairs and Climate Policy and the Ministry of Education, Science, and Culture (Janssen and Abbasiharofteh, 2022). The initial Topsector policy aimed to promote and align the activities of research institutes with that of innovators by fostering coordination and collaboration in the Dutch science and innovation systems of nine sectors (e.g. energy and water technology). Over the course of 2017 it was announced that the Topsector policy would gradually be converted into the Mission-oriented Topsector and Innovation Policy (MTIP), which became effective from 2019 onwards. The MTIP focuses on four cross-sectoral themes (i.e., Energy Transition & Sustainability; Agriculture, Water & Food; Health & Healthcare; and Security) that collectively embody 25 concrete missions (Appendix I). The MTIP, the KIAs, and therefore the innovation projects using the PPP-Allowance now target research programs that can contribute to achieving these missions (Janssen, 2020).

This case study is highly relevant for our research objective because the Netherlands is one of the forerunners in widely deploying mission-oriented innovation policies that address societal challenges. Studying the PPP-Allowance is particularly helpful because the government has compiled an extensive dataset regarding its innovation projects and the missions that they are associated with. Hence, such a case study is helpful in testing our hypotheses (Eisenhardt, 1989).

The data on the content and scope of the collaborative innovation projects is provided by the Netherlands Enterprise Agency (RVO.nl). The full dataset contains information about all projects in the PPP-Allowance program from 2017 to 2019. This paper focuses on projects that started in 2017 or later. In 2017, organisations executing the PPP-Allowance have started to assign mission labels. These labels included in the dataset were refined via semantic techniques and extensive manual checks by RVO.nl, which acts as the central agency for collecting project information and storing it into a dataset in which also organisation names are homogenised.[2]

Although mission labels were assigned to projects from 2017 onwards, the actual shift from Topsector policy to MTIP only started to take shape in 2019. This implies that in the 2017–2019 period projects were hardly subjected to policies that actively promoted mission themes. Furthermore, the participation of public actors did not form a condition for the acquisition of funding. As a result, these aspects allow us to assess whether projects that innovate in line with missions have a de facto tendency to mobilise the public.

Examining this requires us to also take into account that projects in the PPP-Allowance scheme are created with the help of so-called Top-consortia for Knowledge and Innovation (TKI), which act as orchestrating entities in both the initial and current version of the national coordination-based innovation policy strategy. In their capacity as 'systemic innovation intermediaries' (Janssen et al., 2020), the TKIs operate as brokers between organisations that could complement each other in terms of the knowledge they can provide or that they are searching for. Each project is administered to RVO.nl by one of the 12 TKIs, that focus on a sectoral ecosystem (as they were established under the initial Topsector policy). In our analyses, we will control for the differential influence TKIs may have on project team formation and thus on public participation.

Besides information on whether a project fits a research program with relevance for missions (and if so, which mission), the dataset also contains details on issues such as project budget, technological maturity, the identity of formal participants, and their financial involvement in the project. Combining such project and project team characteristics allows us to construct variables on higher degrees of public participation, i.e. whether public actors have full control, delegated power, or influence through partnerships.

3.2. Variables

3.2.1. Dependent variables: intensity, openness, and quality

As mentioned, this study measures public participation in R&I projects through three effectiveness indicators that form the dependent variables of our analysis, i.e., intensity, openness, and quality. *Intensity* relates to how early the public is involved in R&I. The dataset provides project-level data on its development stage and distinguishes between the stages 'fundamental' (upstream; Technology Readiness Level 1–3), 'applied' (midstream; Technology Readiness Level 4–6), and 'experimental' (downstream; Technology Readiness Level 7–8).[3] A high intensity participation is therefore characterised by projects that formally involve public actors in upstream stages. The data contains information on the budget per phase. This paper considers *intesity* a nominal variable that indicates the earliest of the three developmental stages in which the public is financially committed to the respective project. *Intensity* can therefore refer to upstream participation (1), midstream participation (2), downstream participation (3), or no participation (4).

Openness refers to how easily the public can partake in projects and is suggested to be measured through the number and diversity of public participants (Callon et al., 2009). In order to do so, one first needs to define and classify the types of public actors that partake in R&I projects. Various stakeholder categorization methods and typologies have emerged in the last decades (e.g., Bianchi and Kossoudji, 2001; De Lopez, 2001; Mitchell et al., 1997; Savage et al., 1991). While stakeholder categorization is preferably done in collaboration with the stakeholders themselves (Reed et al., 2009), this was not feasible due to the size of the database.

Instead, we use the standardized organization classification (SBI-code) of the Dutch Central Agency for Statistics (CBS) to minimise biases. This code is a widely used multi-digit classification that links every registered organisation to a particular group according to their line of work. The first digit refers to the respective branch (e.g. healthcare) and the second digit indicates a subgroup (e.g., hospital, paramedical practice). SBI-codes are useful for this study because only registered organisations qualify for the PPP-Allowance. As a result, no *individual* actors, such as citizens, are reflected in the data. We retrieved the SBI-code per organisation from the dataset (Table 12, Appendix IV) and computed the number and diversity of public participants.

Number is the count of organisations that classify as public participants. *Diversity* is computed by dividing a project's number of *unique* public participant types (U), as based on the SBI-codes, by the total number of organisations participating in the project (T). Unique public participant types concerns the number of different SBI-codes, with multiple participants per SBI-code counted as one participant type. Dividing U by T allows us to control for project team size. We thus test Hypotheses 2a and 2b by computing the differences between mission/non-mission projects in solely their *number* and their *diversity*, respectively.

The *quality* of public participation refers to the influence of the public in R&I projects. The economic influence is particularly important as investments directly contribute to the ability to influence decision-making and innovate in line with a mission. Influence is relative, hence the economic influence of the public should be considered in light of the economic influence of other actors. Therefore, this study uses the project's total public investments divided by the total investments as a proxy for *quality*.

[2] Some techniques for assigning mission labels were also applied retroactively before 2017, but since these techniques were less robust, we focus on the period for which we have the most reliable and consistent labels.

[3] Technology Readiness Level (TRL) as based on the European Union H2020 2014 model, which was adapted from the former NASA TRL model (Héder, 2017).

3.2.2. Independent variable: mission

We constructed an independent variable, *mission,* to understand how public participation in R&I projects differs between mission-oriented and conventional projects (see Table 1). This variable indicates whether a project falls under the category 'non-mission' (1) or one of the four mission themes, i.e., Energy Transition & Sustainability (2), Agriculture, Water & Food (3), and Health & Healthcare (4), Security (5), and insufficient information (6). These themes represent a constellation of coherent missions. As a result, this variable allows us to test whether mission-oriented projects indeed exhibit different degrees of public participation. Additionally, we also inspect whether public participation, as captured by our three measures, differs for the various mission themes.

3.2.3. Control variables

This study uses control variables to enhance the robustness of the analysis (Table 1). As mentioned, the TKIs at the heart of MTIP (formerly Dutch Topsector policy) act as brokers between parties in a particular domain (e.g. Delta Technology). Because intermediaries contribute to network building, we control for *TKI* using the dataset's project categorisation, which classifies projects according to 12 TKIs with typically a sectoral orientation.

Further, as the topic of public participation may gain or lose prominence in society, the participatory performance of a project may change due to broader societal trends rather than whether or not public participants belong to a mission. Hence, we control for the *start date* of a project.

Table 1
Operationalisation table.

Variable type	Variable	Attribute	Scale	Definition
Dependent variables	Intensity		Nominal	Nominal variable indicating 'upstream participation' (1), 'midstream participation' (2), 'downstream participation' (3), or 'no participation' (4).
	Openness			Participation openness is composed of the aspects *number* and *diversity*.
		Number	Ratio	Count of public participants.
		Diversity	Ratio	Count of unique public participants (by SBI-code) relative to the total number of participants in a project.
	Quality		Ratio	Total public investments divided by total investments.
Independent variable	Mission		Nominal	Categorical variable indicating 'non-mission' (1), 'Energy Transition & Sustainability' (2), 'Agriculture, Water & Food' (3), 'Health & Healthcare' (4), 'Security' (5), and 'insufficient information' (6).
Control	TKI		Nominal	Classification according to 12 TKIs: Agriculture & Food (1), Biobased Economy (2), Chemical Engineering (3), Creative Industry (4), Delta Technology (5), Energy (6), High Tech Systems & Materials (7), Logistics (8), Life Science & Health (9), Maritime (10), Horticulture & Vegetative Propagation (11), and Water Technology (12).
	Start date		Ratio	Year of the first project report as the proxy for the project's start year. This proxy is chosen as it is much more widely available compared to the project's start date.

3.3. Data analysis

The data analysis consists of four individual statistical analyses as we consider four dependent variables that each relate to one of the three dimensions of public participation, i.e., *intensity*, *openness* (*number*), *openness* (*diversity*), and *quality*. We estimate whether the variables, *mission* (themes), *TKI*, and *start date* correlate with the respective participation effectiveness indicators.

Intensity is estimated with a multinomial logistic regression, given that it is a categorical variable. The model provides the probability (0–1) that missions correlate with public participation in particular stages.

Openness consists of integer non-negative values. The Poisson distribution would be suitable to estimate this model but requires that variance and mean to be equal (Sun and Zhao, 2013). As the variable is overdispersed (variance exceeds the mean), we use a negative binomial model instead, which is more suitable in this case. *Number*, one constituent of *openness*, is the count of public actors in a project and consists of positive integer values. *Diversity*, the other constituent of *openness*, is a fraction that takes values in the unit interval, including 0 and 1, and is estimated with a fractional logistic regression (Papke and Wooldridge, 1996). This is a frequently used approach with fractional outcome variables (Adegbesan and Higgins, 2010).

Quality is the share of public investments in total project investments and takes values in the unit interval, including 0 and 1. Again, a fractional logit model is used to estimate the models (Papke and Wooldridge, 1996).

4. Results

This section first briefly describes the dataset and subsequently presents the results of the statistical tests per dependent variable, i.e. *intensity*, *openness*, and *quality* of public participation.

4.1. Descriptive statistics

Table 2 contains the summary project statistics of the ratio variables. Table 3 contains tabulations for the categorical variables. The data contains 1,261 projects involving 7,570 actors (6,896 conventional actors (91.1%) and 674 public actors (8.9%)). While 306 (24.3%) of these projects are not associated with a mission theme, 274 (21.7%) are linked

Table 2
Summary project statistics of ratio variables.

Variables	Mean	Std. dev.	Min	Max
Openness				
Diversity	0.040	0.113	0	1
Number of unique public participant types (by SBI-code)	0.179	0.461	0	4
Total number of participants	3.067	2.850	1	44
Number	0.265	0.828	0	12
Quality	0.040	0.125	0	1
Total public investment	34,868.55	323,556.4	0	6,850,000
Total investment	673,160.7	2,068,355	3889	48,900,000
Start date	2018.035	0.830	2017	2019

Table 3
Tabulations of categorical variables.

Variables	Frequency	Percent
Intensity		
1. Upstream participation	56	4.44
2. Midstream participation	135	10.71
3. Downstream participation	15	1.19
4. No participation	1,055	83.66
Total	1,261	100.00
TKI		
1. Agriculture & Food	54	4.28
2. Biobased Economy	23	1.82
3. Chemical Engineering	76	6.03
4. Creative Industry	23	1.82
5. Delta Technology	82	6.50
6. Energy	114	9.04
7. High Tech Systems & Materials	320	25.38
8. Logistics	332	26.33
9. Life Science & Health	31	2.46
10. Maritime	97	7.69
11. Horticulture & Vegetative Propagation	43	3.41
12. Water Technology	66	5.23
Total	1,261	100.00
Mission		
1. No mission	306	24.27
2. Energy Transition & Sustainability	274	21.73
3. Agriculture, Water & Food	196	15.54
4. Health & Healthcare	395	31.32
5. Security	22	1.74
6. Insufficient information	68	5.39
Total	1,261	100.00

to Energy Transition & Sustainability, 196 (15.5%) to Agriculture, Water & Food, 395 (31.3%) to Health & Healthcare, and 22 (1.7%) to Security. On average, a project comprises 3.1 participants, of which 0.26 are public participants. Table 3 contains tabulations of the categorical variables.

4.2. *Intensity*

Given the nominal nature of *intensity*, several multinomial logistic regressions were run to understand the relation between a project's mission orientation and the timing of public participation. Table 10 (Appendix II) contains a model with *intensity* as the dependent variable and the control variables *TKI* and *start date*, but not the independent variable *mission*. Table 11 (Appendix III) contains *intensity* and the independent variable, *mission*. Table 4, below, contains the full model.

The model containing controls only (Table 10, Appendix II) shows significant differences in participation across TKIs. For example, projects in the Maritime TKI are significantly less likely to have midstream participation than the base category, Agriculture & Food. Furthermore, the significant coefficients of *start date* show that more recent projects are less likely to have upstream and downstream participation compared to the base category, no participation.

Table 11 (Appendix III) shows the independent variables. It shows that projects that fall under the mission themes Energy Transition & Sustainability (2), Agriculture, Water & Food (3) and Health & Healthcare (4) differ from the base category, no mission. Security (5) is only weakly significant. Projects in mission 2, 3, and 4 are more likely to have upstream public participation, and projects in missions 2 and 3 are more likely to have midstream participation than projects without a mission, compared to the base of no participation.

The full model in Table 4 shows that across the board, the characteristic of mission orientation – as opposed to non-mission orientation – predicts upstream and midstream participation, except for Security. The finding that individual missions do not generally predict downstream participation can be seen as further support for the hypothesis that

Table 4
Intensity: results of the full model.

	(1)	(2)	(3)
	Multinomial logistic regression		
	Dependent variable: intensity (base level: 4. No participation)		
Variables	1. Upstream participation	2. Midstream participation	3. Downstream participation
Mission			
1. No mission			
2. Energy Transition &	0.977	1.539***	−0.0145
Sustainability	(0.988)	(0.486)	(1.472)
3. Agriculture, Water &	3.061***	1.521***	−11.51
Food	(1.033)	(0.570)	(947.0)
	2.200**	−0.483	1.075
4. Health & Healthcare	(0.940)	(0.726)	(1.197)
	3.185**	0.784	2.464*
5. Security	(1.378)	(0.904)	(1.363)
6. Insufficient	0.304	1.128*	−14.75
information	(1.192)	(0.627)	(1.522)
TKI			
Agriculture & Food	0	0	0
(1)	(base)	(base)	(base)
Biobased Economy	−13.11	−0.759	−0.316
(2)	(1.672)	(0.875)	(3.288)
Chemical	1.404	−15.20	−0.721
Engineering (3)	(1.312)	(629.7)	(2.292)
	3.724**	1.260	15.70
Creative Industry (4)	(1.452)	(0.875)	(1.627)
	0.748	1.058**	1.022
Delta Technology (5)	(1.184)	(0.477)	(2.271)
	3.436***	−0.422	15.08
Energy (6)	(1.230)	(0.588)	(1.627)
High Tech Systems &	0.442	−1.136*	13.35
Materials (7)	(1.294)	(0.619)	(1.627)
	2.074*	0.985	14.37
Logistics (8)	(1.196)	(0.731)	(1.627)
Life Science &	−12.85	1.525**	−0.235
Health (9)	(1.616)	(0.679)	(2.606)
	1.401	−1.017	0.707
Maritime (10)	(1.511)	(0.779)	(2.079)
Horticulture &	1.204	1.323**	1.420
Vegetative			
Propagation (11)	(1.261)	(0.529)	(2.890)
Water Technology	1.396	1.291**	−0.558
(12)	(1.258)	(0.506)	(3.191)
	−0.505***	−0.229*	−1.126***
Start date	(0.184)	(0.131)	(0.398)
	1.012***	459.6*	2.254
Constant	(370.7)	(265.1)	(1.815)
Observations / pseudo-R2		1,261 / 0.193	

Standard errors in parentheses.
*** $p < 0.01$
** $p < 0.05$
* $p < 0.1$

mission-oriented projects exhibit public participation in an earlier phase than non-mission-oriented projects.

4.3. *Openness*

Openness of participation is composed of the variables *number* and *diversity*. We define *diversity* as the number of unique public participants (by SBI-code) relative to all participants in a project. To reiterate, Hypotheses 2a and 2b state that mission-oriented projects have a higher number, and greater diversity, of public participants than non-mission-oriented projects. Table 5 shows estimations with respect to *number* (models 1–3), and *diversity* (models 4–6). The first model of each batch (models 1 and 4) comprises the controls only, the second model (models 2 and 5) the independent variable only, and the last model (models 3 and 6) all variables.

With the number of public participants in a project as the dependent variable, models 1–3 show that mission themes Energy Transition & Sustainability, Agriculture, Water & Food, and Security significantly predict *number*, supporting Hypothesis 2a. The overall picture regarding *diversity* is quite different. The full model shows that only Agriculture, Water & Food is a significant predictor of *diversity*. This shows that mission-oriented projects are not structurally different from non-mission projects in terms of *diversity*, rejecting Hypothesis 2b.

4.4. Quality

We operationalise *quality* as the total public investment divided by the total investment in a project. Since this quality measure is a proportion that takes values in the unit interval (i.e. 0 and 1), we use a fractional logit regression to estimate the results. Model 1 in Table 6 contains the independent variable *mission* only, model 2 contains the controls only, and model 3 represents the full model. In model 1, all coefficients are significant, except the mission Security. Controlling for *start date* and *TKI* in model 3 changes this picture. The significance disappears in model 3 after adding the control variables *TKI* and *start date*. Mission categories 3 and 5 are now statistically significant. Comparing models 2 and 3, it is evident however that the addition of *mission* to the controls does not improve the fit of the model in any substantive way.

The point estimates of the fractional logistic regression are not

Table 5
Openness: Regression results regarding the constituents.

	(1)	(2)	(3)	(4)	(5)	(6)
	Negative binomial regression			Fractional logistic regression		
Variables	Dependent variable: **number**			Dependent variable: **diversity**		
1. No mission		0 (base)	0 (base)		0 (base)	0 (base)
2. Energy Transition & Sustainability		1.769*** (0.309)	1.320*** (0.381)		0.860** (0.402)	0.896* (0.476)
3. Agriculture, Water & Food		2.460*** (0.310)	1.521*** (0.429)		1.531*** (0.393)	1.239** (0.500)
4. Health & Healthcare		1.505*** (0.302)	0.521 (0.488)		0.865** (0.395)	0.220 (0.527)
5. Security		1.469** (0.641)	1.316** (0.663)		0.647 (0.691)	1.062 (0.673)
6. Insufficient information		1.504*** (0.424)	0.885* (0.487)		1.121** (0.546)	1.190** (0.532)
TKI						
Agriculture & Food (1)	0 (base)		0 (base)	0 (base)		0 (base)
Biobased Economy (2)	−0.207 (0.694)		−0.135 (0.726)	−0.642 (0.778)		−0.642 (0.776)
Chemical Engineering (3)	−2.033** (0.817)		−1.713** (0.847)	−1.388 (0.917)		−1.040 (0.911)
Creative Industry (4)	0.334 (0.630)		1.483** (0.716)	1.857*** (0.635)		2.774*** (0.642)
Delta Technology (5)	1.415*** (0.424)		1.297*** (0.429)	1.173*** (0.415)		1.027** (0.416)
Energy (6)	0.344 (0.435)		0.475 (0.491)	0.495 (0.442)		0.585 (0.471)
High Tech Systems & Materials (7)	−1.297*** (0.450)		−0.633 (0.503)	−0.998** (0.474)		−0.377 (0.552)
Logistics (8)	0.297 (0.396)		1.100* (0.563)	0.415 (0.398)		1.204** (0.500)
Life Science & Health (9)	0.522 (0.553)		1.110* (0.621)	0.158 (0.505)		0.654 (0.581)
Maritime (10)	−1.219** (0.601)		−0.569 (0.652)	−1.299* (0.726)		−0.878 (0.772)
Horticulture & Vegetative Propagation (11)	1.339*** (0.473)		1.239*** (0.477)	0.945** (0.467)		0.775 (0.475)
Water Technology (12)	1.538*** (0.432)		1.546*** (0.456)	1.157*** (0.430)		1.143*** (0.429)
Start date	−0.259*** (0.0944)		−0.321*** (0.0975)	−0.191* (0.104)		−0.219** (0.104)
Constant	520.1*** (190.5)	−2.951*** (0.269)	645.6*** (196.7)	382.7* (209.5)	−4.062*** (0.369)	437.1** (209.2)
Observations	1,261	1,261	1,261	1,261	1,261	1,261

Standard errors in parentheses.
*** $p < 0.01$
** $p < 0.05$
* $p < 0.1$

Table 6
Quality: results from a fractional logistic regression.

	(1)	(2)	(3)
	Fractional logistic regression		
Variables	Dependent variable: **quality**		
Mission			
1. No mission	0		0
	(base)		(base)
2. Energy Transition & Sustainability	0.935**		0.970*
	(0.468)		(0.557)
3. Agriculture, Water & Food	1.754***		1.173**
	(0.461)		(0.582)
4. Health & Healthcare	1.161**		−0.262
	(0.460)		(0.700)
5. Security	1.122		1.820***
	(0.699)		(0.596)
6. Insufficient information	1.111*		1.131*
	(0.636)		(0.653)
TKI			
Agriculture & Food (1)		0	0
		(base)	(base)
Biobased Economy (2)		0.215	0.107
		(0.832)	(0.834)
Chemical Engineering (3)		−1.158	−0.908
		(0.976)	(0.980)
Creative Industry (4)		2.240***	3.118***
		(0.734)	(0.748)
Delta Technology (5)		1.893***	1.684***
		(0.505)	(0.505)
Energy (6)		0.464	0.419
		(0.574)	(0.596)
High Tech Systems & Materials (7)		−0.771	−0.331
		(0.576)	(0.678)
Logistics (8)		1.143**	2.285***
		(0.489)	(0.618)
Life Science & Health (9)		−0.112	0.0901
		(0.639)	(0.678)
Maritime (10)		−1.758**	−1.474*
		(0.715)	(0.760)
Horticulture & Vegetative Propagation (11)		1.381**	1.185**
		(0.568)	(0.570)
Water Technology (12)		1.833***	1.731***
		(0.511)	(0.529)
Start date		−0.333***	−0.358***
		(0.112)	(0.113)
Constant	668.5***	−4.223***	717.0***
	(225.9)	(0.435)	(228.6)
Pseudo R2	0.031	0.110	0.120
Observations	1,261	1,261	1,261

Robust standard errors in parentheses.
*** $p < 0.01$
** $p < 0.05$
* $p < 0.1$

directly interpretable (Ai and Norton, 2003). Table 7 shows predictive margins for the third model (calculated with Stata's *margins* command), and Table 8 shows average marginal effects compared to the base category (category 1 no mission). The marginal effects (dy/dx) is the change in *quality* over the base category (mission category 1 in Table 7) in percentage points.

Table 7 shows that all mission-oriented projects have higher predictions for *quality* than non-mission projects. The base, 'no mission', has a predicted conditional mean of quality of 3%, meaning that, on average, total public investments have a share of 3% in total investments. Security has the highest predicted conditional mean of 13.9%, an improvement of 10.9 percentage points over the base category. However, the confidence intervals of the average marginal effects in Table 8 indicate several themes to reach below zero, showing that the association between mission orientation and *quality* is subject to uncertainty. Hence, we find limited support for Hypothesis 3 that public participants have more influence in mission-oriented than in non-mission-oriented R&I projects.

5. Discussion and conclusion

This paper quantitatively examined whether mission-oriented innovation projects are associated with earlier (*intensity*), more open (*openness*), and more influential (*quality*) public participation than non-mission-oriented projects. This section briefly discusses the findings, after which it elaborates on the implications and future research.

5.1. Findings

Our results suggest that mission-oriented projects are not always associated with earlier, more open, and more influential public participation than conventional projects. However, the mission theme appears decisive in this regard.

When specifically considering *intensity* we find that various themes – in particular Agriculture, Water & Food – predict upstream and midstream participation, in contrast to downstream participation. Only the mission theme Security does not correlate significantly with earlier participation. We speculate that this may be subject to (one of) the following two explanations: (1) the confidentiality associated with security issues may impede the involvement of the public, and (2) the relatively small sample size of projects that fall within Security may have influenced the results.

Findings in relation to *openness* show that the mission theme Agriculture, Water & Food is also associated with more open projects, both in terms of their number and diversity of public participants. Notably, this theme fosters openness even when highly related TKIs such as Delta Technology and Water Technology do as well. The number of public participants in Energy Transition & Sustainability and Security is

Table 7
Quality: predicted margins.

Mission	Margin	Delta method standard error	z	P > |z|	[95 % conf. interval]	
1. No mission	0.030	0.016	1.85	0.064	−0.002	0.061
2. Energy Transition & Sustainability	0.071	0.022	3.15	0.002	0.027	0.114
3. Agriculture, Water & Food	0.084	0.022	3.80	0.000	0.041	0.127
4. Health & Healthcare	0.023	0.005	5.02	0.000	0.014	0.032
5. Security	0.139	0.061	2.28	0.023	0.019	0.258
6. Insufficient information	0.081	0.033	2.42	0.016	0.015	0.146

Table 8
Quality: average marginal effects.

Mission	dy/dx	Delta method Standard error	z	P > |z|	[95 % conf. interval]	
1. No mission	(base)					
2. Energy Transition & Sustainability	0.041	0.022	1.86	0.063	−0.002	0.084
3. Agriculture, Water & Food	0.054	0.024	2.29	0.022	0.008	0.100
4. Health & Healthcare	−0.006	0.018	−0.35	0.727	−0.043	0.030
5. Security	0.109	0.055	1.98	0.047	0.001	0.217
6. Insufficient information	0.051	0.033	1.55	0.120	−0.013	0.116

likewise greater than in conventional projects. Except for Agriculture, Water & Food, no other theme explains the diversity of public participation.

Compared to non-mission-oriented projects, the *quality* of participation (i.e. the relative economic influence of the public) is the highest for mission-oriented projects linked to Agriculture, Water & Food, and Security. Energy Transition & Sustainability and Health & Healthcare do not predict the quality of public participation.

Because participation appears to depend on the specific mission theme, the hypothesised relationships are obscured at the aggregate level. When comparing missions, it appears that the theme Agriculture, Water & Food is characterised most by public participation. This could be due to the important role of environmental agencies, governmental bodies, NGOs, and civil society organisations in realizing more resilient deltas and sustainable food systems. The mission theme Health & Healthcare did not predict public participation. In practice, the public may be involved in lower degrees of engagement such as co-design and citizen science. These lower engagement approaches are linked to inferior information flows (Arnstein, 1969; Hurlbert and Gupta, 2015), and may lower the responsiveness of projects to inclusive, anticipatory, and reflexive insights (Stilgoe et al., 2013).

Furthermore, one of the findings that stand out is the potential influence some TKIs have on the projects' participatory performance. We find that TKIs such as Creative Industry, Delta Technology, and Water Technology are consistently linked to earlier, more open, and more influential public participation than Agriculture & Food (the TKI baseline). Similarly, Horticulture & Vegetative Propagation and Logistics also correlate positively with multiple participatory indicators. We see two possible reasons why some TKIs positively influence public participation. First, some of these intermediaries have an important brokerage role in network formation and bringing parties together (De Silva et al., 2018; Howells, 2006). Our results indicate that for several TKIs, this is likewise the case for the involvement of public parties. Second, various TKIs relate to particular domains (e.g. creative industry) that may be more proximate to the public. These TKIs could be more dependent on the public for market validation or support, and may therefore encourage participation. This would explain why TKIs such as Chemical Engineering, Maritime, and High Tech Systems & Materials – those less dependent on public validation and support – are not associated with increased public participation.

A last noteworthy finding is that the *start date* of projects has a negative relationship with all dependent variables except for midstream participation. Indeed, missions evolve over time (Wanzenböck et al., 2020). Our results show that the more recent Dutch mission-oriented projects are less inclined to involve the public, suggesting that the 2019 effectuation of policies supporting the turn towards mission-oriented projects has backfired with respect to encouraging public participation. At this point, it is unclear whether this observation is specifically characteristic for the MTIP (including its particular policy priorities and instruments) or whether resorting to university-industry-dominated project teams is just an initial response to any change in the national policy strategy.

5.2. Theoretical contributions and policy implications

This paper contributes to theory and practice in various ways. It helps actors understand what to expect from a mission's participatory performance and thus contributes to debates on mission-oriented innovation policy (Foray et al., 2012; Mazzucato, 2017), public participation (Rowe and Frewer, 2000, 2005), and in a broader sense the literature on challenge-led innovation policy (Haddad et al., 2022; Schot and Steinmueller, 2018) and responsible innovation (Stilgoe et al., 2013; Wiarda et al., 2021).

Scholars and policymakers frequently frame missions as promising policy instruments to unite actors towards a shared direction (Edler and Fagerberg, 2017; Mowery et al., 2010; Robinson and Mazzucato, 2019). However, this study finds that the mobilisation of public actors is not self-evident and therefore prompts caution. Whether a mission orientation encourages public participation through full control, delegated power, or influence through partnerships – i.e. what Arnstein (1969) called 'higher degrees of power' – is predominantly determined by the mission theme. The constellation of missions that fall under these themes seems to stimulate earlier (upstream and midstream) and, in many cases, more (number) public participation. However, these missions tend to lack a diversity of public participants, and the influence they can exert seems limited in light of their relative economic resources.

While missions aim to address societal challenges that tend to affect society as a whole, the limited diversity in their projects may result in neglecting certain values and worldviews that are nevertheless crucial for the effectiveness and desirability of mission outcomes. As Wanzenböck et al. (2020) point out, agreeing on what problems/resolutions efforts should be directed, requires diverse input of heterogeneous stakeholders with the aim of lowering contestation and fostering collective action. Policymakers can increase this missions' diversity by co-creating and framing them more inclusively, making them resonate with a larger spectrum of stakeholders.

Furthermore, the public's limited economic influence hints that the extent to which R&I is directed and shaped according to public values and worldviews presumably depends on the willingness of conventional actors. The public's lack of financial resources may require targeted funding. However, increasing other forms of influence likely requires policymakers to go beyond mere financial instruments and, for instance, pay specific attention to politics and power imbalances (Van Oudheusden, 2014).

While missions are linked to an increased number of public participants, we find that this is not accompanied with an increased diversity of public participants. This is problematic because resolving wicked problems necessitates learning from diverse and conflicting worldviews (Cuppen, 2012; Schot and Steinmueller, 2018). Missions that fail to mobilise a broad range of publics risk overlooking the input of those actors affected by societal challenges, and those related to the resolution's implementation (Wanzenböck and Frenken, 2020). They moreover jeopardize overlooking the variety of concerns (Latour, 2004) and emotions (Roeser, 2012) that emerge from value conflicts (Smith, 2003). This may give rise to the false impression that ideas about problems and required resolutions are widely shared (Wanzenböck et al., 2020). By extension, missions may risk reflexivity failures (Weber and Rohracher, 2012) as they struggle more than others to cope with the inherent complexity, uncertainty, and contestation linked to their wicked problems of interest (Head, 2008). This is expected to particularly be problematic for so called 'transformer' missions, which provoke more contestation than more technology-oriented 'accelerator' missions (Fisher et al., 2018).

Our study indicates that intermediaries can enhance missions' public participatory performances. While it is widely acknowledged that innovation intermediaries have a brokerage role between two or more parties (De Silva et al., 2018; Howells, 2006), we present empirical evidence that for some intermediaries this is also the case between conventional parties and the public. In our study, this especially holds for those linked to the Creative Industry, Delta Technology, and Water Technology. In some cases deploying intermediaries can be a promising policy instrument to mobilise the public.

Although this paper has not examined this empirically, it is expected that inclusive mission arenas give rise to fundamental disagreement and conflict (Wanzenböck et al., 2020; Wesseling and Meijerhof, 2021). Policymakers, intermediaries, and project teams will have to navigate these through, for instance, constructive or agonistic approaches that enhance mutual learning, avoid stand-stills, and prompt legitimate ways forward (Popa et al., 2021).

5.3. Limitations and future research

We present some initial evidence on the extent to which missions mobilise actors and reveal substantial differences in their ability to do so for the public. Although we provide possible explanations for why this may be the case, future research is needed to validate these speculations. Likewise, more research is required to better understand why certain innovation intermediaries are better at including the public than others.

It is important to stress a few limitations of this study. First, the definitions and operationalisations used in this study affect the results. As mentioned, there is no consensus on how to measure public participation. We recognise that this can be done in various ways, and we would like to emphasise that our approach is not the only valid one. Second, we have selected the Netherlands as our empirical environment. Yet, it is unclear whether our findings can be generalised to other regions. Future research could validate whether this is the case.

Moving forward, several other avenues stand out for future studies. Research could explore to what extent the public engages with missions in lower degrees of power (Arnstein, 1969) through for instance advisory committees, focus groups, or consensus conferences (Rowe and Frewer, 2000). These engagement forms focus on consulting and informing the public (Rowe and Frewer, 2005) and therefore contribute differently to missions than formal participation. Lower degrees of power were unfortunately not reflected in our dataset.

Moreover, we yield insight regarding the participatory performance of funded projects that find themselves in Technology Readiness Level 1–8. To further understand the participatory nature of MIPs throughout their life cycle, future research could examine the public's involvement before projects are funded, i.e. public participation in mission creation and project funding. In addition, a longitudinal analysis could complement our cross-sectional analysis by examining the temporal character of public participation in mission-oriented projects.

Furthermore, we need to better understand *how* the public contributes to mission-oriented projects, especially in light of the limited diversity and influence of the public. This likely requires specific attention to the politics of deliberation (Van Oudheusden, 2014).

Lastly, we lack an understanding of whether public participation can materialise the (implicit) instrumental and substantive promises that are made vis-à-vis missions. In other words, does public participation lead to more rewarding and successful mission outcomes? And what are the potential downsides of public participation? Researching this will contribute to a better understanding of what forms of public mobilization are desirable for missions.

CRediT authorship contribution statement

Martijn Wiarda: Conceptualization, Methodology, Data curation, Writing – original draft, Writing – review & editing, Project administration. **Vladimir C.M. Sobota:** Conceptualization, Methodology, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Matthijs J. Janssen:** Conceptualization, Methodology, Resources, Data curation, Writing – review & editing, Supervision. **Geerten van de Kaa:** Writing – review & editing, Supervision, Funding acquisition. **Emad Yaghmaei:** Writing – review & editing, Supervision, Funding acquisition, Project administration. **Neelke Doorn:** Conceptualization, Writing – review & editing, Supervision, Funding acquisition, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix I

Table 9
The Dutch mission-oriented topsector and innovation policy's missions per theme (Ministry of EZK, 2019).

Theme	Missions
Energy transition & sustainability	49 % reduction of national greenhouse gas emissions by 2030, aiming for 95 % lower emissions by 2050 compared to 1990. An entirely carbon-free electricity system by 2050. A carbon-free built environment by 2050. Carbon-neutral industry with reuse of raw materials and products by 2050. Zero-emission mobility of people and goods by 2050. A sustainable and completely circular economy by 2050, with resource use halved by 2030.
Agriculture, water & food	Reduction of the use of raw and auxiliary materials in agriculture and horticulture by 2030 and creating the maximum possible value from all end products and residuals by utilizing them as fully as possible (circular agriculture). By 2050, the agricultural and nature system will be net carbon-neutral (Joint mission with energy transition and sustainability). The Netherlands will be climate-proof and water-resilient by 2050 By 2030, we will produce and consume healthy, safe and sustainable food, while supply chain partners and farmers get a fair price for their produce. A sustainable balance between ecological capacity and water management vs. renewable energy, food, fishing and other economic activities, where this balance must be achieved by 2030 for marine waters and by 2050 for rivers, lakes and estuaries. The Netherlands is and will remain the best-protected and most viable delta in the world, with timely future-proof measures implemented at a manageable cost.
Health & healthcare	By 2040, all Dutch citizens will live at least five years longer in good health, while the health inequalities between the lowest and highest socio-economic groups will have decreased by 30 %. By 2040, the burden of disease resulting from an unhealthy lifestyle and living environment will have decreased by 30 % By 2030, the extent of care provided to people within their own living environment (rather than in health-care institutions) will be 50 % more than today or such care will be provided 50 % more frequently than at present. By 2030, the proportion of people with a chronic disease or lifelong disability who can play an active role in society according to their wishes and capabilities will have increased by 25 %. By 2030, quality of life for people with dementia will have improved by 25 %.

(*continued on next page*)

Table 9 (*continued*)

Theme	Missions
Security	By 2030, organized crime in the Netherlands will have become an excessively high-risk and low-return enterprise, thanks to a better insight into illegal activities and cash flows. By 2035, the Netherlands will have a navy fit for the future, which will be able to respond flexibly to unpredictable and unforeseen developments. By 2030, the Netherlands will have operationally deployable space-based capabilities for defense and security. Cyber security: the Netherlands will be in a position to capitalize, in a secure manner, on the economic and social opportunities offered by digitization. By 2030, the armed forces will be fully networked with other services and through the integration of new technologies, so that they can act faster and more effectively than the opponent. Supply and demand will come together more quickly to implement successful short-cycle innovations By 2030, security organisations will be capable of collecting new and better data, so that they are always one step ahead of the threat. By 2030, the role of security professional will be among the 10 most attractive professions in the Netherlands

Appendix II

Table 10
Intensity: Controls only.

	(1)	(2)	(3)
	Multinomial logistic regression		
	Dependent variable: intensity (base level: 4. No participation)		
Variables	1. Upstream participation	2. Midstream participation	3. Downstream participation
TKI			
Agriculture & Food (1)	0 (base)	0 (base)	0 (base)
Biobased Economy (2)	−14.73 (2.160)	−0.527 (0.846)	−0.465 (4.545)
Chemical Engineering (3)	0.138 (1.241)	−15.82 (798.3)	−0.384 (3.201)
Creative Industry (4)	1.715 (1.262)	0.160 (0.747)	16.58 (2.396)
Delta Technology (5)	0.931 (1.175)	1.308*** (0.469)	−0.582 (3.710)
Energy (6)	1.712 (1.059)	−0.248 (0.518)	15.37 (2.396)
High Tech Systems & Materials (7)	−0.909 (1.168)	−1.802*** (0.543)	14.54 (2.396)
Logistics (8)	1.582 (1.032)	−0.676 (0.465)	16.07 (2.396)
Life Science & Health (9)	−14.63 (2.173)	0.989* (0.567)	−0.172 (4.485)
Maritime (10)	−0.538 (1.429)	−1.493** (0.715)	0.222 (2.979)
Horticulture & Vegetative Propagation (11)	1.531 (1.256)	1.513*** (0.521)	0.00727 (4.785)
Water Technology (12)	0.841 (1.246)	1.486*** (0.480)	−0.803 (4.502)
Start date	−0.462*** (0.179)	−0.158 (0.125)	−1.077*** (0.395)
Constant	929.4*** (360.6)	316.4 (251.8)	2.155 (2.525)
Observations / pseudo-R2		1.261 / 0.166	

Standard errors in parentheses.
*** $p < 0.01$
** $p < 0.05$
* $p < 0.1$

Appendix III

Table 11
Intensity: Independent variable only.

	(1)	(2)	(3)
	Multinomial logistic regression		
	Dependent variable: intensity (base level: 4. No participation)		

(*continued on next page*)

Table 11 (*continued*)

	(1)	(2)	(3)
	Multinomial logistic regression		
	Dependent variable: intensity (base level: 4. No participation)		
Variables	1. Upstream participation	2. Midstream participation	3. Downstream participation
Variables	1. Upstream participation	2. Midstream participation	3. Downstream participation
Mission			
1. No mission	0 (base)	0 (base)	0 (base)
2. Energy Transition & Sustainability	1.887** (0.780)	1.769*** (0.380)	0.277 (1.004)
3. Agriculture, Water & Food	2.430*** (0.782)	2.666*** (0.374)	−11.87 (403.8)
4. Health & Healthcare	2.610*** (0.734)	0.668 (0.409)	1.478* (0.779)
5. Security	2.097* (1.249)	1.286 (0.819)	2.096* (1.249)
6. Insufficient information	1.603 (1.010)	1.351*** (0.524)	−11.81 (579.0)
Constant	−4.987*** (0.710)	−3.483*** (0.338)	−4.987*** (0.710)
Observations / pseudo-r2		2.213 / 0.093	

Standard errors in parentheses.
*** $p < 0.01$
** $p < 0.05$
* $p < 0.1$

Appendix IV

Table 12
SBI-codes and organisation type.

SBI-code	Type	N
1	Agriculture and related service activities	164
2	Forestry and logging	1
6	Extraction of crude petroleum and natural gas	16
8	Mining and quarrying (no oil and gas)	3
9	Mining support activities	3
10	Manufacture of food products	48
11	Manufacture of beverages	2
13	Manufacture of textiles	9
17	Manufacture of paper and paper products	12
18	Printing and reproduction of recorded media	1
19	Manufacture of coke and refined petroleum products	47
20	Manufacture of chemicals and chemical products	137
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	43
22	Manufacture of rubber and plastic products	15
23	Manufacture of other non-metallic mineral products	18
24	Manufacture of basic metals	15
25	Manufacture of fabricated metal products, except machinery and equipment	53
26	Manufacture of computers, electronic and optical products	141
27	Manufacture of electrical equipment	47
28	Manufacture of machinery and equipment n.e.c.	199
29	Manufacture of motor vehicles, trailers and semi-trailers	14
30	Manufacture of other transport equipment	57
31	Manufacture of furniture	2
32	Manufacture of other products n.e.c	24
33	Repair and installation of machinery and equipment	39
35	Electricity, gas, steam and air conditioning supply	35
36	Collection, purification and distribution of water	201
37	Sewerage	41
38	Waste collection, treatment and disposal activities; materials recovery	22
39	Remediation activities and other waste management	3
41	Construction of buildings and development of building projects	32
42	Civil engineering	69
43	Specialised construction activities	34
45	Sale and repair of motor vehicles, motorcycles and trailers	6
46	Wholesale trade (no motor vehicles and motorcycles)	407
47	Retail trade (not in motor vehicles)	10
49	Land transport	22
50	Water transport	19
51	Air transport	1
52	Warehousing and support activities for transportation	81

(*continued on next page*)

Table 12 (*continued*)

SBI-code	Type	N
53	Postal and courier activities	3
55	Accommodation	2
56	Food and beverage service activities	5
58	Publishing	13
59	Motion picture and television programme production and distribution; sound recording and music publishing	2
61	Telecommunications	16
62	Support activities in the field of information technology	150
63	Information service activities	7
64	Financial institutions, except insurance and pension funding	572
65	Insurance and pension funding (no compulsory social security)	6
66	Other financial services	10
68	Renting and buying and selling of real estate	16
69	Legal services, accounting, tax consultancy, administration	22
70	Holding companies (not financial)	205
71	Architects, engineers and technical design and consultancy; testing and analysis	383
72	Research and development	1.629
73	Advertising and market research	47
74	Industrial design, photography, translation and other consultancy	57
75	Veterinary activities	2
77	Renting and leasing of motor vehicles, consumer goods, machines and other tangible goods	40
78	Employment placement, provision of temporary employment and payrolling	17
79	Travel agencies, tour operators, tourist information and reservation services	2
80	Security and investigation	2
81	Facility management	7
82	Other business services	28
84	Public administration, public services and compulsory social security	290
85	Education	105
86	Human health activities	513
87	Residential care and guidance	3
88	Social work activities without accommodation	32
90	Arts	10
91	Lending of cultural goods, public archives, museums, botanical and zoological gardens and nature reserves activities	13
93	Sports and recreation	3
94	World view and political organisations, interest and ideological organisations, hobby clubs	320

References

Adegbesan, J.A., Higgins, M.J., 2010. The intra-alliance division of value created through collaboration. Strateg. Manag. J. 32, 187–211, 10.1002/smj.

Ai, C., Norton, E.C., 2003. Interaction terms in logit and probit models. Econ. Lett. 80 (1), 123–129. https://doi.org/10.1016/S0165-1765(03)00032-6.

Arnstein, S.R., 1969. A ladder of citizen participation. J. Am. Inst. Plann. 35 (4), 216–224.

Arthur, B., 1989. Competing technologies, increasing returns, and lock-in by historical events. Econ. J. 99 (394), 116–131.

Barney, J., 1991. Firm resources and sustained competitive advantage. J. Manag. 17 (1), 99–120. https://doi.org/10.1177/014920639101700108.

Bauer, A., Bogner, A., Fuchs, D., 2021. Rethinking societal engagement under the heading of responsible research and innovation: (novel) requirements and challenges. J.Responsib.Innov. 1–22. https://doi.org/10.1080/23299460.2021.1909812.

Beierle, T.C., 2002. The Quality of Stakeholder-Based Decisions, 22(4).

Bianchi, R., Kossoudji, S., 2001. Interest groups and organizations as stakeholder. In: Social Development Papers, 35, pp. 1–30. https://www.commdev.org/userfiles/files/1493_file_SDP_35.pdf.

Bijker, W.E., 1995. Of bicycles, bakelites, and bulbs: toward a theory of sociotechnical change. MIT Press.

Borrás, S., Edler, J., 2014. The governance of change in socio-technical and innovation systems: three pillars for a conceptual framework. In: The Governance of Socio-Technical Systems: Explaining Change. Edward Elgar Publishing, pp. 23–48. https://doi.org/10.4337/9781784710194.00011.

Bugge, M.M., Fevolden, A.M., 2019. Mission-oriented innovation in urban governance: setting and solving problems in waste valorisation. In: From Waste to Value: Valorisation Pathways for Organic Waste Streams in Circular Bioeconomies, pp. 91–106. https://doi.org/10.4324/9780429460289-5.

Bulkeley, H., Casta, V., 2013. Government by experiment? Global cities and the governing of climate change. Trans. Inst. Br. Geogr. 361–375. https://doi.org/10.1111/j.1475-5661.2012.00535.x.

Buur, J., Matthews, B., 2008. Participatory innovation. Int. J. Innov. Manag. 12 (3), 255–273. https://doi.org/10.1142/S1363919608001996.

Callon, M., Lascoumes, P., Barthe, Y., 2009. Acting in an Uncertain World an Essay on Technical Democracy. MIT Press.

Cantner, U., Pyka, A., 2001. Classifying technology policy from an evolutionary perspective. Res. Policy 30 (5), 759–775. https://doi.org/10.1016/S0048-7333(00)00104-9.

Chavez, V.A., Stinnett, R., Tierney, R., Walsh, S., 2017. The importance of the technologically able social innovators and entrepreneurs: a US national laboratory perspective. Technol. Forecast. Soc. Chang. 121, 205–215. https://doi.org/10.1016/j.techfore.2016.09.002.

Chesbrough, H., 2003. Open Innovation. Harvard Business School Press.

Chess, C., Purcell, K., 1999. Public participation and the environment: do we know what works? Environ. Sci. Technol. 33 (16), 2685–2692. https://doi.org/10.1021/es980500g.

Collingridge, D., 1980. The Social Control of Technology. St. Martin's Press.

Cuppen, E., 2012. Diversity and constructive conflict in stakeholder dialogue: considerations for design and methods. Policy Sci. 45 (1), 23–46. https://doi.org/10.1007/s11077-011-9141-7.

David, P., 1994. Why are institutions the "carriers of history"?: path dependence and the evolution of conventions, organisations and institutions. Struct. Chang. Econ. Dyn. 5 (2), 205–220.

David, P., 1995. Clio and the economics of QWERTY. In: Ninety-Seventh Annual Meeting of the American Economic Association, <sb:series><sb:title> </sb:title></sb:series>75(2), pp. 332–337.

De Lopez, T.T., 2001. Stakeholder management for conservation projects: a case study of Ream National Park,Cambodia. Environ. Manag. 28 (1), 47–60. https://doi.org/10.1007/s002670010206.

De Silva, M., Howells, J., Meyer, M., 2018. Innovation intermediaries and collaboration: knowledge–based practices and internal value creation. Res. Policy 47 (1), 70–87. https://doi.org/10.1016/j.respol.2017.09.011.

Delgado, A., Kjølberg, K.L., Wickson, F., 2011. Public engagement coming of age: from theory to practice in STS encounters with nanotechnology. Public Underst. Sci. 20 (6), 826–845. https://doi.org/10.1177/0963662510363054.

Diercks, G., Larsen, H., Steward, F., 2019. Transformative innovation policy: addressing variety in an emerging policy paradigm. Res. Policy 48 (4), 880–894. https://doi.org/10.1016/j.respol.2018.10.028.

Dosi, G., 1982. In: Technological Paradigms and Technological Trajectories, 1982, pp. 147–162.

Edler, J., Boon, W.P., 2018. The next generation of innovation policy: directionality and the role of demand-oriented instruments. Sci. Public Policy 45, 433–434.

Edler, J., Fagerberg, J., 2017. Innovation policy: what, why, and how. Oxf. Rev. Econ. Policy 33 (1), 2–23. https://doi.org/10.1093/oxrep/grx001.

Eisenhardt, K.M., 1989. Building theories from case study research. Acad. Manag. 14 (4), 532–550.

Ergas, H., 1987. Does technology policy matter? In: Guile, B., Brooks, H. (Eds.), Technology and Global Industry: Companies and Nations in the World Economy. National Academies Press, pp. 191–245.

European Commission, 2009. Europe Must Focus on the Grand Challenges of Our Time.

European Commission, 2018. Mission-Oriented Research & Innovation in the European Union: A Problem-solving Approach to Fuel Innovation-led Growth.

Ferraro, F., Etzion, D., Gehman, J., 2015. Tackling grand challenges pragmatically: robust action revisited. Organ. Stud. 36 (3), 363–390. https://doi.org/10.1177/0170840614563742.

Fiorino, D.J., 1990. Citizen participation and environmental risk: a survey of institutional mechanisms. Sci. Technol. Hum. Values 15 (2), 226–243. https://doi.org/10.1177/016224399001500204.

Fisher, R., Chicot, J., Domini, A., Polt, W., Turk, A., Unger, M., Kuittinen, H., Arrilucea, E., van der Zee, F., Goetheer, A., Lehenkari, J., Kristensen, F.S., 2018. Mission-Oriented Research and Innovation: Inventory and Characterisation of Initiatives. https://doi.org/10.2777/697082 (Issue April).

Foray, D., 2018. Smart specialization strategies as a case of mission-oriented policy-a case study on the emergence of new policy practices. Ind. Corp. Chang. 27 (5), 817–832. https://doi.org/10.1093/icc/dty030.

Foray, D., Mowery, D.C., Nelson, R.R., 2012. Public R&D and social challenges: what lessons from mission R&D programs? Res. Policy 41 (10), 1697–1702. https://doi.org/10.1016/j.respol.2012.07.011.

Fraaije, A., Flipse, S.M., 2020. Synthesizing an implementation framework for responsible research and innovation. <sb:contribution><sb:title>J. Responsib.</sb:title></sb:contribution><sb:host><sb:issue><sb:series><sb:title>Innov.</sb:title></sb:series></sb:issue></sb:host> 7 (1). https://doi.org/10.1080/23299460.2019.1676685.

Garud, R., Gehman, J., 2012. Metatheoretical perspectives on sustainability journeys: evolutionary, relational and durational. Res. Policy 41 (6), 980–995. https://doi.org/10.1016/j.respol.2011.07.009.

Genus, A., Coles, A.M., 2005. On constructive technology assessment and limitations on public participation in technology aassessment. Technol.Anal.Strateg.Manag. 17 (4), 433–443. https://doi.org/10.1080/09537320500357251.

Godin, B., 2005. The linear model of innovation: the historical construction of an analytical framework. In: Project on the History and Sociology of S&T Statistics. Working Paper No. 30. https://doi.org/10.1007/BF02832074.

Godin, B., Lane, J.P., 2013. Pushes and pulls: hi(s)tory of the demand pull model of innovation. Sci.Technol.Hum.Values 38 (5), 621–654. https://doi.org/10.1177/0162243912473163.

Grillitsch, M., Hansen, T., Coenen, L., Miörner, J., Moodysson, J., 2019. Innovation policy for system-wide transformation: the case of strategic innovation programmes (SIPs) in Sweden. Res. Policy 48 (4), 1048–1061. https://doi.org/10.1016/j.respol.2018.10.004.

Grinbaum, A., Groves, C., 2013. In: What Is "Responsible" About Responsible Innovation? Understanding the Ethical Issues. Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society, April 2013, pp. 119–142. https://doi.org/10.1002/9781118551424.ch7.

Haddad, C.R., Nakić, V., Bergek, A., Hellsmark, H., 2022. Transformative innovation policy: a systematic review. Environ.Innov.Soc.Transit. 43 (March 2021), 14–40. https://doi.org/10.1016/j.eist.2022.03.002.

Head, B.W., 2008. Wicked problems in public policy. Public Policy 3 (2), 101–118.

Héder, M., 2017. From NASA to EU: the evolution of the TRL scale in public sector innovation. Innov.J.Public Sect.Innov.J. 22 (2), 1–23.

Hekkert, M.P., Janssen, M.J., Wesseling, J.H., Negro, S.O., 2020. Mission-oriented innovation systems. Environ.Innov.Soc.Transit. 34 (January), 76–79. https://doi.org/10.1016/j.eist.2019.11.011.

Hossain, M., 2016. Grassroots innovation: a systematic review of two decades of research. J. Clean. Prod. 137 (September 2015), 973–981. https://doi.org/10.1016/j.jclepro.2016.07.140.

Howells, J., 2006. Intermediation and the role of intermediaries in innovation. Res. Policy 35 (5), 715–728. https://doi.org/10.1016/j.respol.2006.03.005.

Huizingh, E.K.R.E., 2011. Open innovation: state of the art and future perspectives. Technovation 31 (1), 2–9. https://doi.org/10.1016/j.technovation.2010.10.002.

Hurlbert, M., Gupta, J., 2015. The split ladder of participation: a diagnostic, strategic, and evaluation tool to assess when participation is necessary. Environ. Sci. Policy 50, 100–113. https://doi.org/10.1016/j.envsci.2015.01.011.

Janssen, M.J., 2020. Post-commencement Analysis of the Dutch 'Mission-oriented Topsector and Innovation Policy' Strategy.

Janssen, M.J., Abbasiharofteh, M., 2022. Boundary spanning R&D collaboration: key enabling technologies and missions as alleviators of proximity effects? Technol. Forecast. Soc. Chang. 180 (June 2021), 121689 https://doi.org/10.1016/j.techfore.2022.121689.

Janssen, M.J., Bogers, M., Wanzenböck, I., 2020. Do systemic innovation intermediaries broaden horizons? A proximity perspective on R&D partnership formation. Ind. Innov. 27 (6), 605–629. https://doi.org/10.1080/13662716.2019.1618701.

Janssen, M.J., Torrens, J., Wesseling, J.H., 2021. The promises and premise of mission-oriented innovation policy - a reflection and ways forward. Sci. Public Policy. https://doi.org/10.1093/scipol/scaa072.

Janssen, M.J., Wesseling, J., Torrens, J., Weber, M., Penna, C., Klerkx, L., 2023. Missions as boundary objects for transformative change: understanding coordination across policy, research and stakeholder communities. Sci. Public Policy 00, 1–18.

Jasanoff, S., 2003. Technologies of humility: citizen participation governing science. Minerva 41, 223–244.

Kattel, R., Mazzucato, M., 2018. Mission-oriented innovation policy and dynamic capabilities in the public sector. Ind. Corp. Chang. 27 (5), 787–801. https://doi.org/10.1093/icc/dty032.

Kearnes, M., Macnaghten, P., Wilsdon, J., 2006. Governing at the nanoscale: people, policies and emerging technologies. Demos. www.demos.co.uk.

Kline, S.J., Rosenberg, N., 1986. An overview of innovation. In: Studies on Science and the Innovation Process: Selected Works of Nathan Rosenberg.

Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M.S., Wells, P., 2019. An agenda for sustainability transitions research: state of the art and future directions. Environ.Innov.Soc.Transit. 31, 1–32. https://doi.org/10.1016/j.eist.2019.01.004.

Koontz, T.M., Thomas, C.W., 2006. What do we know and need to know about the environmental outcomes of collaborative management? Public Adm. Rev. 66 (Suppl. 1), 111–121. https://doi.org/10.1111/j.1540-6210.2006.00671.x.

Kuhlmann, S., Rip, A., 2014. The Challenge of Addressing Grand Challenges.

Kuhlmann, S., Rip, A., 2018. Next-generation innovation policy and grand challenges. Sci. Public Policy 45 (February), 448–454. https://doi.org/10.1093/scipol/scy011.

Kuhn, T., 1962. The Structure of Scientific Revolutions. The University Chicago Press.

Latour, B., 2004. Why has critique run out of steam? From matters of fact to matters of concern. Crit. Inq. 30 (2), 225. https://doi.org/10.2307/1344358.

Linder, R., Stefan, K., Randles, S., Bedsted, B., Gorgoni, G., Griessler, E., Loconto, A., Mejlgaard, N., 2016. Navigating towards shared responsibility. http://pure.au.dk/portal/files/98634660/RES_AGorA_ebook.pdf.

Linton, J.D., Walsh, S.T., 2004. Roadmapping: from sustaining to disruptive technologies. Technol. Forecast. Soc. Chang. 71 (1–2), 1–3. https://doi.org/10.1016/j.techfore.2003.10.004.

Loorbach, D., Rotmans, J., 2010. The practice of transition management: examples and lessons from four distinct cases. Futures 1–10. https://doi.org/10.1016/j.futures.2009.11.009.

Lynam, T., De Jong, W., Sheil, D., Kusumanto, T., Evans, K., 2007. A review of tools for incorporating community knowledge, preferences, and values into decision making in natural resources management. Ecol. Soc. 12 (1).

Marino, K.E., 1996. Developing consensus on firm competencies and capabilities. Acad. Manag. Exec. 10 (3), 40–51. https://doi.org/10.5465/ame.1996.9704111473.

Mazmanian, D., Nienaber, J., 1980. Can Organizations Change?, Vol. 20, Issue 4.

Mazzucato, M., 2016. From market fixing to market-creating: a new framework for innovation policy. Ind. Innov. 23 (2), 140–156. https://doi.org/10.1080/13662716.2016.1146124.

Mazzucato, M., 2017. Mission-oriented innovation policy. In: UCL Institute for Innovation and Public Purpose Working Paper, p. 1.

Mazzucato, M., 2018a. Mission-oriented innovation policies: challenges and opportunities. Ind. Corp. Chang. 27 (5), 803–815. https://doi.org/10.1093/icc/dty034.

Mazzucato, M., 2018b. Mission-oriented Research & Innovation in the European Union. A Problem-solving Approach to Fuel Innovation-led Growth, Vol. 58, Issue 1. https://doi.org/10.2777/36546.

Mazzucato, M., Robinson, D.K.R., 2018. Co-creating and directing innovation ecosystems? NASA's changing approach to public-private partnerships in low-earth orbit. Technol. Forecast. Soc. Chang. 136, 166–177. https://doi.org/10.1016/j.techfore.2017.03.034.

Ministry of EZK, 2019. Dutch Missions for Grand Challenges.

Mitchell, R.K., Agle, B.R., Wood, D.J., 1997. Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. Acad. Manag. Rev. 22 (4), 853–886. https://doi.org/10.5465/AMR.1997.9711022105.

Moore, A., 2010. Beyond participation: opening up political theory in STS. Soc. Stud. Sci. 40 (5), 793–799. https://doi.org/10.1177/0306312710383070.

Mowery, D.C., Nelson, R.R., Martin, B.R., 2010. Technology policy and global warming: why new policy models are needed (or why putting new wine in old bottles won't work). Res. Policy 39 (8), 1011–1023. https://doi.org/10.1016/j.respol.2010.05.008.

Nelson, R.R., 1974. Intellectualizing about the moon-ghetto metaphor: a study of the current malaise of rational analysis of social problems. Policy Sci. 5 (4), 375–414. https://doi.org/10.1007/BF00147227.

Newig, J., 2007. In: Does public participation in environmental decisions lead to improved environmental quality, 1(October 2001). CCP (Communication, Cooperation, Participation. Research and Practice for a Sustainable Future), pp. 51–71. http://www.usf.uni-osnabrueck.de/~jnewig/03_Forschung_Newig_final.pdf.

Newig, J., Fritsch, O., 2009. Participatory governance and sustainability. Findings of a meta-analysis of stakeholder involvement in environmental decision-making. In: Reflexive Governance in the Public Interest. MIT Press, pp. 1–28.

Newig, J., Kvarda, E., 2012. Participation in environmental governance: legitimate and effective?. In: Environmental Governance. The Challenge of Legitimacy and Effectiveness, Issue January. Edward Elgar, pp. 89–108. https://doi.org/10.4337/9781849806077.00013.

Owen, R., Macnaghten, P., Stilgoe, J., 2012. Responsible research and innovation: from science in society to science for society, with society. Sci. Public Policy 39 (6), 751–760. https://doi.org/10.1093/scipol/scs093.

Papke, L.E., Wooldridge, J.M., 1996. Econometric methods for fractional response variables with an application to 401 (k) plan participation rates. J. Appl. Econ. 11 (6), 619–632. https://doi.org/10.1002/(SICI)1099-1255(199611)11:6<619::AID-JAE418>3.0.CO;2-1.

Pesch, U., Huijts, N.M.A., Bombaerts, G., Doorn, N., Hunka, A., 2020. Creating 'local publics': responsibility and involvement in decision-making on technologies with local impacts. Sci. Eng. Ethics 26 (4), 2215–2234. https://doi.org/10.1007/s11948-020-00199-0.

Pidgeon, N., Parkhill, K., Corner, A., Vaughan, N., 2013. Deliberating stratospheric aerosols for climate geoengineering and the SPICE project. Nat. Clim. Chang. 3 (5), 451–457. https://doi.org/10.1038/nclimate1807.

Pinch, T., Bijker, W.E., 1984. The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other. Soc. Stud. Sci. 14, 399–441.

Popa, E.O., Blok, V., Wesselink, R., 2021. An agonistic approach to technological conflict. Philos.Technol. 34 (4), 717–737. https://doi.org/10.1007/s13347-020-00430-7.

Prahalad, C.K., Hamel, G., 1990. The core competence of the corporation. Harv. Bus. Rev. 1–15. https://doi.org/10.1016/b978-0-7506-7223-8.50003-4.

Prahalad, C.K., Hamel, G., 1994. Strategy as a field of study: why search for a new paradigm? C. K. Prahalad; Gary hamel strategic management journal, Vol. 15, Special issue: strategy: search for new paradigms. (Summer, 1994), pp. 5-16. Strateg. Manag. J. 15, 5–16.

Rabadjieva, M., Terstriep, J., 2021. Ambition meets reality: mission-oriented innovation policy as a driver for participative governance. Sustainability 13 (1), 231. https://doi.org/10.3390/su13010231.

Raymond, E., 1999. The Cathedral & the Bazaar. O'Reilly & Associates Inc.

Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141 (10), 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014.

Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H., Stringer, L.C., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. J. Environ. Manag. 90 (5), 1933–1949. https://doi.org/10.1016/j.jenvman.2009.01.001.

Rittel, H., Webber, M., 1973. Dilemmas in a general theory of planning. Policy Sci. 4, 155–196. https://doi.org/10.1080/01636609209550084.

Robinson, D.K.R., Mazzucato, M., 2019. The evolution of mission-oriented policies: exploring changing market creating policies in the US and European space sector. Res. Policy 48 (4), 936–948. https://doi.org/10.1016/j.respol.2018.10.005.

Roeser, S., 2012. Risk communication, public engagement, and climate change: a role for emotions. Risk Anal. 32 (6), 1033–1040. https://doi.org/10.1111/j.1539-6924.2012.01812.x.

Rosener, J., 1981. User-oriented evaluation: a new way to view citizen participation. J. Appl. Behav. Sci. 17 (4), 583–596.

Roth, F., Wittmann, F., Hufnagl, M., Lindner, R., 2021. Putting Mission-oriented Innovation Policies to Work: A Case Study of the German High-Tech Strategy 2025, Issue 75.

Rowe, G., Frewer, L.J., 2000. Public participation methods: a framework for evaluation. Sci.Technol.Hum.Values 25 (1), 3–29. https://doi.org/10.1177/016224390002500101.

Rowe, G., Frewer, L.J., 2004. Evaluating public-participation exercises: a research agenda. Sci.Technol.Hum.Values 29 (4), 512–557. https://doi.org/10.1177/0162243903259197.

Rowe, G., Frewer, L.J., 2005. A typology of public engagement mechanisms. Sci.Technol. Hum.Values 30 (2), 251–290. https://doi.org/10.1177/0162243904271724.

Savage, G.T., Nix, T.W., Whitehead, C.J., Blair, J.D., 1991. Strategies for assessing and managing organizational stakeholders. Acad. Manag. Exec. 5 (2), 61–75. https://doi.org/10.5465/ame.1991.4274682.

Scharpf, F.W., 1997. Economic integration, democracy and the welfare state. J.Eur. Public Policy 4 (1), 18–36. https://doi.org/10.1080/135017697344217.

Scharpf, F.W., 1999. Governing in Europe: Effective and Democratic? Oxford University Press.

Schmidt, V.A., 2013. Democracy and legitimacy in the European Union revisited: input, output and "throughput". Polit.Stud. 61 (1), 2–22. https://doi.org/10.1111/j.1467-9248.2012.00962.x.

Schot, J., Kanger, L., Verbong, G.P.J., 2016. The roles of users in shaping transitions to new energy systems. Nat. Energy 1 (2016), 1–7. https://doi.org/10.1038/nenergy.2016.54.

Schot, J., Steinmueller, W.E., 2018. Three frames for innovation policy: R&D, systems of innovation and transformative change. Res. Policy 47 (July), 1554–1567. https://doi.org/10.1016/j.respol.2018.08.011.

Schumpeter, J., 1934. The Theory of Economic Development. Springer.

Seyfang, G., Smith, A., 2007. Grassroots innovations for sustainable development: towards a new research and policy agenda. Environ.Polit. 16 (4), 584–603. https://doi.org/10.1080/09644010701419121.

Shanley, D., Cohen, J.B., Surber, N., Stack, S., Shanley, D., Cohen, J.B., Surber, N., Stack, S., Shanley, D., 2022. Looking beyond the 'horizon' of RRI: moving from discomforts to commitments as early career researchers discomforts to commitments as early career researchers. J.Responsib.Innov. https://doi.org/10.1080/23299460.2022.2049506.

Smith, A., Fressoli, M., Thomas, H., 2014. Grassroots innovation movements: challenges and contributions. J. Clean. Prod. 63, 114–124. https://doi.org/10.1016/j.jclepro.2012.12.025.

Smith, G., 1983. Impact Assessment and Sustainable Resource Management. Longman.

Smith, G., 2003. Deliberative Democracy and the Environment. Psychology Press.

Stahl, B.C., 2013. Responsible research and innovation: the role of privacy in an emerging framework. Sci. Public Policy 40 (6), 708–716. https://doi.org/10.1093/scipol/sct067.

Steen, M., Nauta, J., 2020. Advantages and disadvantages of societal engagement: a case study in a research and technology organization. J.Responsib.Innov. 7 (3), 598–619. https://doi.org/10.1080/23299460.2020.1813864.

Stilgoe, J., Owen, R., Macnaghten, P., 2013. Developing a framework for responsible innovation. Res. Policy 42 (9), 1568–1580. https://doi.org/10.1016/j.respol.2013.05.008.

Stirling, A., 2008. "Opening up" and "closing down": power, participation, and pluralism in the social appraisal of technology. Sci.Technol.Hum.Values 33 (2), 262–294. https://doi.org/10.1177/0162243907311265.

Stirling, A., 2010. Keep it complex. Nature 468 (1031).

Suchman, M.C., 1995. Managing legitimacy: strategic and institutional approaches. Acad. Manag. Rev. 20 (3), 571. https://doi.org/10.2307/258788.

Sun, J., Zhao, X., 2013. Statistical Analysis of Panel Count Data, Vol. 80. Springer, New York.

Surie, G., 2017. Creating the innovation ecosystem for renewable energy via social entrepreneurship: insights from India. Technol. Forecast. Soc. Chang. 121, 184–195. https://doi.org/10.1016/j.techfore.2017.03.006.

Sutcliffe, H., 2011. In: A report on responsible research & innovation. … Research and Innovation of the European …, pp. 1–77. http://www.matterforall.org/pdf/RRI-Report2.pdf.

Sykes, K., Macnaghten, P., 2013. Responsible innovation - opening up dialogue and debate. In: Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society. John Wiley & Sons, Inc., pp. 85–107. https://doi.org/10.1002/9781118551424.ch5

van de Vrande, V., de Jong, J.P.J., Vanhaverbeke, W., de Rochemont, M., 2009. Open innovation in SMEs: trends, motives and management challenges. Technovation 29 (6–7), 423–437. https://doi.org/10.1016/j.technovation.2008.10.001.

Van den Hoven, J., Jacob, K., Nielsen, L., Roure, F., Rudze, L., Stilgoe, J., Blind, K., Guske, A.-L., Riera, C., 2013. Options for Strengthening Responsible Research and Innovation.

Van Oudheusden, M., 2014. Where are the politics in responsible innovation? European governance, technology assessments, and beyond. J.Responsib.Innov. 1 (1), 67–86. https://doi.org/10.1080/23299460.2014.882097.

von Hippel, E., 1988. The Sources of Innovation. Oxford University Press Inc.

von Hippel, E., 2005. Democratizing Innovation. MIT Pres.

Von Schomberg, R., 2013. A vision of responsible research and innovation. In: Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society, Issue June 2013. https://doi.org/10.1002/9781118551424.ch3.

Wanzenböck, I., Frenken, K., 2020. The subsidiarity principle in innovation policy for societal challenges. Glob.Transit. 2, 51–59. https://doi.org/10.1016/j.glt.2020.02.002.

Wanzenböck, I., Wesseling, J.H., Frenken, K., Hekkert, M.P., Weber, K.M., 2020. A framework for mission-oriented innovation policy: alternative pathways through the problem–solution space. Sci. Public Policy 47 (July), 474–489. https://doi.org/10.1093/scipol/scaa027.

Weber, K.M., Rohracher, H., 2012. Legitimizing research, technology and innovation policies for transformative change: combining insights from innovation systems and multi-level perspective in a comprehensive "failures" framework. Res. Policy 41 (6), 1037–1047. https://doi.org/10.1016/j.respol.2011.10.015.

Wesseling, J.H., Meijerhof, N., 2021. Developing and Applying the Mission-oriented Innovation System (MIS) Approach.

West, J., Bogers, M., 2014. Leveraging external sources of innovation: a review of research on open innovation. J. Prod. Innov. Manag. 31 (4), 814–831. https://doi.org/10.1111/jpim.12125.

Wiarda, M., van de Kaa, G., Yaghmaei, E., Doorn, N., 2021. A comprehensive appraisal of responsible research and innovation: from roots to leaves. Technol. Forecast. Soc. Chang. 172, 121053 https://doi.org/10.1016/J.TECHFORE.2021.121053.

Wilsdon, J., Willis, R., 2004. See-through Science. Why Public Engagement Needs to Move Upstream. Demos. https://doi.org/10.1038/scientificamerican1014-27a.

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