Fraunhofer
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Impact Assessment of Mission-Oriented Policies

Challenges and overview of selected existing approaches

Karlsruhe, May 2021

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Abbreviations

MOIP	Mission-oriented Innovation Policy
MIS	Mission-oriented innovation System
R&D	Research and Development
R&I	Research and Innovation
TIS	Technological Innovation System
TRL	Technology Readiness Level

1   Introduction

This report is part of the scientific support action to the German Hightech Strategy 2025.The support action firstly provides evidence-based scientific policy consultation for the implementation of the current Hightech Strategy. Secondly, by offering in-depth insights into selected missions and their diverse instruments and approaches, it supports the development of a framework for measuring the impacts of mission-oriented policy approaches.

The study of impacts of mission-oriented innovation policies (MOIPs) has been on the innovation scholar agenda for quite some time. Yet, an established methodology for conceptualizing and measuring the impacts of transformative innovation policies/complex settings in general and MOIP in particular is still lacking (Weber and Polt 2014, p. 9; Hekkert et al. 2020, p. 77; Amanatidou et al. 2014; Janssen 2016; Arnold et al. 2018, pp. 16–18; Grillitsch et al. 2019).

To better understand the specificities, requirements and challenges inherent to measuring the impacts of MOIPs, this report provides an overview of the most important challenges and promising approaches on impact assessment of MOIP. These are considered to offer valuable insights and guidance for the design and further development of a framework that is tailored to the specific requirements of conceptualizing and assessing the impacts of MOIPs.

In this report, we take an explorative approach on reviewing and summarizing selected existing approaches related to MOIPs and complement them with insights from impact assessment research more generally. This task is a foundational step for the development of a novel framework for impact assessment of MOIP at a later stage of our research project. Throughout the project we draw on the following definition by Larrue (2021, p. 15) of MOIP:

> *"A mission-oriented innovation policy is a coordinated package of policy and regulatory measures tailored specifically to mobilize science, technology and innovation in order to address well-defined objectives related to a societal challenge, in a defined timeframe. These measures possibly span different stages of the innovation cycle from research to demonstration and market deployment, mix supply-push and demand-pull instruments, and cut across various policy fields, sectors and disciplines."*

This document is structured as follows: Following this introduction, section 2 provides an overview of the various types of challenges in the context of impact assessment and evaluation of MOIPs. Identifying these challenges can contribute to a better understanding of the requirements of a new framework and provide an analytical lens for the review of selected existing approaches. Section 3 provides an overview of current literature from evaluation and impact assessment research related to mission-oriented policies (MOIP)

and programs. By identifying and discussing current research's strengths, limitations and opportunities, this section provides the basis for the development of a novel analytical framework. In section 4, we present several approaches from different fields of research that could help to address the identified challenges. To conclude, section 5 summarizes the key insights of this report and derives implications for the design of a novel framework to evaluate and assess the impacts of MOIP.

2   Challenges of MOIP for Impact Assessment and evaluation

Mission-oriented innovation policies (MOIP) aim for linking research and innovation policies with grand societal challenges by providing directionality and a cross-sectoral and multidisciplinary approach that combines a wider variety of policy-instruments (Kuittinen et al. 2018, p. 23). Consequently, there has been a discussion about the implications for evaluation practices mission-oriented innovation policies (Amanatidou et al. 2014). Teirlink et al. (2011, p. 29) argue that such changes "require a new methodological and indicator framework" (see also Walz 2016). Sandin et al. (2019) contend that existing evaluation tools provide a good starting point, but require multiple adjustments (see also Arnold 2004).

As a first step for a systemic overview of the state of research, this section offers a structured outline of key conceptual and empirical challenges and implications for evaluation and impact assessment. In sum, we identify six main issues related to understanding the effects and dynamics of MOIPs as transformative policies.[1]

- Challenge 1: Breadth of scope for analysis and multi-dimensionality of impacts

The first set of challenges is centered around the question on the key focus of the evaluation. The in-built directionality and orientation towards grand societal challenges reaches beyond traditional perspectives of evaluation by having a considerably wider scope (Edler et al. 2012; Amanatidou et al. 2014; Arnold et al. 2018, p. 2). MOIP do not only aim for technological change, but in many instances also for changes at the societal level, including behavioral changes, and in consequence comprise the whole policy cycle (Kuittinen et al. 2018, p. 61). Therefore, impact assessment needs to incorporate a wider range of impact dimensions crossing disciplinary boundaries or as Amanatidou et al. (2014, p. 435) argue "need to overcome fragmentation at various levels, i.e. in scientific disciplines, institutions and policy areas".[2]

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[1]   For a discussion about the similarities and differences of the transition perspective and mission-orientation see Arnold et al. (2019, p. 17).

[2]   At the same time, the directionality increases the need for indicators reflecting goal achievement (Walz 2016, p. 16).

This creates obstacles of capturing the relevant dimensions of impact. While there is a number of established dimensions of impact, such as economic, societal, environmental, there is no blueprint which types of impact should be necessarily considered. Existing research (for a compilation see e.g. European Science Foundation 2012, p. 5) has high-lighted a plethora of dimensions, such as scientific/technological/economic/social/political/environmental/health/cultural/training impacts. The problem of identifying relevant impact dimensions however, gains even more importance against the background of the notion that results fostered by MOIP can be both intended vs. unintended and expected vs. unexpected (Amanatidou et al. 2014). The challenge therefore is to identify relevant areas of impact despite blurry boundaries and finding the appropriate metrics for it (Joly and Matt 2017).

This point is also taken up by Hekkert et al. (2020) who highlight the need for a new perspective (Mission-oriented innovation system, MIS), given the new difficulties to define boundaries of a mission. The emergence of missions around problems instead of solutions and the combination of technical and non-technical innovations creates difficulties to delineate from the very beginning the relevant actors for the realization of a mission. Depending on the translation process from challenge to mission, the results can be highly different, due to the prioritization and the formulation process of goals.

- Challenge 2: Interconnectedness of dynamics and impacts

Closely related to this first bundle of challenges, research has pointed to the importance of interconnections and dependencies.[3] Complex programs face a "'quadruple helix' of government, science, industry and wider society and address the need for far-reaching changes across the responsibilities of different ministries and in the ways many different parts of society function" (Arnold et al. 2018, p. 52). Miedzinski et al. (2013) point out that impacts on different dimensions might not follow a uniform pattern, but might even run counter to each other, creating complex interaction effects (see also Weber and Polt 2014). While technological change in one area might support the achievement of a mission goal, at the same time, changes at the societal level might hamper adequate changes in behavior. The fact that missions draw on a mix of different policy instruments (Kuittinen et al. 2018, p. 65; for a more general perspective on policy mixes see Rogge and Reichardt 2016) imposes new requirements for impact assessment, as the established approaches fail to understand the interaction, conflicts and synergies between different types of instruments (Janssen 2016). In case of missions such dynamics may

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3   Cf. also Rogers (2008, pp. 32–35) who argues that complexity in evaluation is caused by the existence of multiple actors, the existence of simultaneous or alternative causal strands, the non-linearity of effects and emergent outcomes. For a review on the interlinkage between theories of complexity and evaluation see e.g. Walton (2014; 2016b).

even take place at the level of grand societal challenges that affect each other (such as climate change and resource availability) (Amanatidou et al. 2014, p. 425).

- Challenge 3: Long-term materialization of impacts

Another challenge of studies of MOIP and transformative policies is related to the temporal dimension. As Amanatidou et al. (2014, p. 425) highlight, "the long-term approach that is necessary in dealing with grand challenges raises difficulties in attributing impacts to specific policy measures and also clashes with the short-termism of policymaking cycles". Moving away from the focus on outputs that might be detected towards the end of the implementation period, impacts may materialize only with considerable delay and thus beyond the timeframe of a mission/program (Kuittinen et al. 2018, p. 67). In particular, the multidimensional character implies that impacts in different domains materialize at different points of time, making it difficult to grasp all impacts simultaneously. Figure 1 displays an example for different time horizons of anticipated effects, indicating the difficulty for determining the „right" point in time of capturing effects.

Figure 1:   Example for time horizons for dynamics of RTI
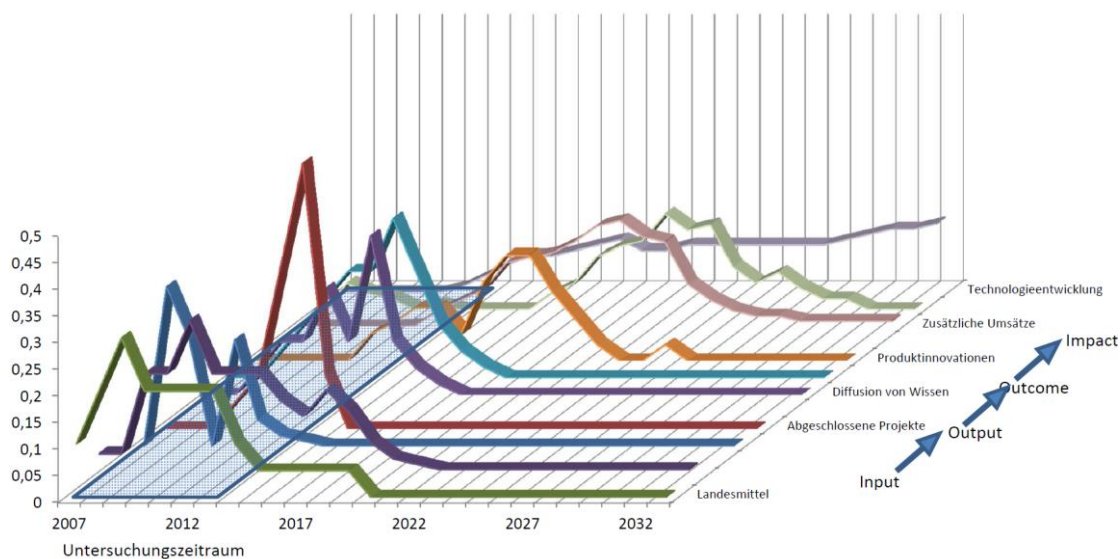
Source: Rothgang (2021, p. 7)

- Challenge 4: Existence of multiple levels of analysis

Next, MOIPs entail challenges with regard to the level of evaluation. Kuittinen et al. (2018, pp. 62-64) emphasize that the realization of impacts in case of missions goes through different phases, moving from the micro- to the meso-/macro-level, making it necessary to distinguish between impact processes and impact levels. The impact of these policies might not be found at the level of intervention, as changes target higher

levels (Weber and Polt 2014, p. 6) and might be assessed differently by actors at different levels, making the assessment highly contested (Barnes et al. 2003). In a similar vein, Amanatidou et al. (2014, p. 437) highlight that so far most evaluation focus on the operational level neglecting the effects at the system level emerging from the interplay for technological development, policy activities (as well as policy learning) and governance that characterizes MOIPs (see also Magro and Wilson 2013).

- Challenge 5: New motivations for evaluation and guiding questions

Moreover, the turn towards transformative changes requires evaluation to provide different perspectives on the motivation, focus, approach and responsibilities (Magro and Wilson 2019). Focusing on smart specialization strategies, the authors argue that the shift in goals, the emphasis on directionality, and the complexity of governance with multiple stakeholders facilitates a reorientation of evaluation: it moves away from the summative goal to provide accountability towards a formative approach that can provide "strategic intelligence through evaluation that is trusted and seen as legitimate by all parties" (ibid., p. 8). A similar perspective is echoed by Sandin et al. (2019) who emphasize the "great potential to support" the realization of transition processes, by bringing together evaluation theory with transition research and policy analysis. Consequently, there is a shift from ex-post summative evaluations, towards a stronger focus on ex-ante and formative components (Kuittinen et al. 2018, p. 67; Weber and Polt 2014). Introducing complex policies with multidimensional goals and greater stakeholder involvement, there is an increasing demand for building up sufficient capacity and increasing learning effects among policy makers (Janssen 2016; Magro and Wilson 2019; Arnold et al. 2018).

- Challenge 6: Empirical diversity of missions and varying interpretations of mission-orientation

Finally, at an empirical level, there is an increasing diversity of policies that is subsumed under the label of mission-oriented policy (for overviews see e.g. Kuittinen et al. 2018; Larrue et al. 2019; Polt et al. 2019; Wittmann et al. 2020a). This may have multiple origins. First of all, even if missions might address the same societal challenge, the approach to tackle it and even the definition might be completely different, which needs to be acknowledged (Edler and Salas Gironés 2020; Wittmann et al. 2020a). Secondly, the degree of mission-orientation may vary considerable. Kuittinen et al. (2018, p. 23) analyze a total of seven case studies of different types of programs and policies to assess the level of mission orientation. In none of the instances one finds that a program meets all relevant criteria for mission-orientation. In this context, Griniece and Sorokins (2018) emphasize that not all challenges might be equally suited for a mission-oriented approach. Furthermore, Hekkert et al. (2020) highlight that depending on the chosen goals, constellations may vary over time and across space, making an analysis highly complex.

Finally, some of the initiatives that received the label of MOIP might not fit the definition and transformative ambition in the first place but can be most likely referred to as "old wine in new bottles"[4].

3   Approaches for impact assessment and evaluation of MOIP

The rise of mission-orientation as a prevalent concept for the design of innovation and research policies in the past years, has led to a number of empirical analysis of MOIP (Janssen 2020; Wittmann et al. 2020b; Larrue 2021; Kuittinen et al. 2018). These studies have focused on different elements like governance arrangements, the scope of missions and their positioning in the socio-technical system and cross-country comparative studies. However, there is not yet an established framework for measuring the impacts of MOIPs (Weber and Polt 2014, p. 9; Hekkert et al. 2020, p. 77) and for transformative innovation policies within complex settings in general (Amanatidou et al. 2014; Janssen 2016; Arnold et al. 2018, pp. 16–18; Grillitsch et al. 2019).[5] This section provides a brief overview over existing approaches that explicitly relate to impact assessment and evaluation of MOIP and study those at an empirical level.

3.1   Innovation system approaches

A first strand of literature approaches the problem of impact assessment in MOIP from the perspective of innovation systems, in particular approaches focusing on technological innovation systems (TIS). These concepts focus on potential bottlenecks that might prevent the realization of the aspired goals. Acknowledging that established frameworks are not capable of capturing transformative change, Janssen (2016) proposes a modification of the TIS approach in order to study transformative policies. The framework is built around three major steps: the assessment of policy design, changes in the socio-technical system based on the contribution of public policies in altering these functions,

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4   See also the article by Daimer et al. (2012, p. 175): "imposing grand challenges as a major rationale of policy and hence a major goal of research and development by a top-down organized process will most likely not lead to any real transformative innovation, but will rather lead to subsuming previous research under new headlines like putting 'old wine into new bottles'".

5   The JIIP Global Observatory of Mission-Oriented R&I (http://www.jiip.eu/mop/wp/) lists 44 initiatives around the globe. Among those, not even one fifth of cases contained an ex-ante assessment of societal criteria, thus an assessment reaching beyond socio-economic factors. In a similar vein, three case studies among complex programs (HTS – Germany, Top Sectors – Netherlands, UK Climate Change Act – United Kingdom) by Arnold et al. (2018, p. 42-48), indicate the difficulties of evaluation approaches given a multilevel structure and the shift towards societal impacts, requiring measurements at the systemic level. For instance, the initial evaluation strategy of the Dutch Top Sectors relying on quantitative indictors required a major revision, given the increasing shift towards societal impacts.

and finally changes in the economic and knowledge structures. At the first stage, it is assessed how closely the policy design of the case under study matches the underlying requirements for transformative policy with regard to policy organization and orientation (Janssen 2016, pp. 19–20). Next, the policy impact assessment focuses on the different functions in a TIS and asks about governmental activities, their effectiveness and decisiveness for outcomes. Thereby, policy choices and policy impulses are likely to be closely connected (Janssen 2016, p. 24). Finally, certain types of outputs observed can be related back to distinct system functions, allowing to understand changing structures in economy and knowledge.

While this approach provides an institutional baseline to understand how missions are actually managed and strives for delineating the role of interventions, the approach for narrowly-targeted transformative policies might not be easily translated to the broader approach of MOIP. The question is how to move from a focus on technological systems to the world of mission-oriented politics that usually address multiple, socio-technical sub-systems and reach beyond technology-driven goals only. A focus on TIS might be hence to narrow and a framework would need to provide insights into the interaction between different sub-systems that reach beyond an individual TIS.

This aspect has been taken up by Hekkert et al. (2020), who call for the need of developing a Mission-oriented innovation system (MIS). Thereby, they argue that MIS are temporally-limited and centered on problems instead of solutions. In consequence, they result in specific combinations of public and private actors and may exhibit different spatial structures.

A first attempt in this direction offer Wesseling and Meijerhof (2020) with their analytical framework for MIS, which they apply to the case of the Dutch water transportation sector. Differentiating between a mission arena of the core actors and an overall MIS that is supposed to be mobilized through the key actors, they propose a set of analytical steps (problem-solutions diagnosis, structural analysis, functional analysis, system barriers analysis) with analytical questions. At the heart of this approach is a modified TIS framework that alters and complements TIS functions with those that are specific to MOIP approaches, like problem- and solution-directionality or reflexivity.

Table 1:   Analytical questions for different levels of analysis (based on Wesseling and Meijerhof 2020)

Problem-solution analysis:
• How do different societal problems and 'wants' relate to the mission?
• What technological and social solutions are relevant to the mission?
• How radically innovative are these solutions and what is their state of technical (Technology-Readiness Level-TRL) and market development?
• How do the identified solutions interact (symbiosis, neutralism, parasitism, commensalism and amensalism)?

Structural analysis

- What actors are involved in the mission formulation?
- What actors are involved in mobilizing other MIS components in pursuit of the mission?
- What actors are involved in the continued governance of the mission?
- What actions have these actors undertaken for the above three purposes?
- What actors, networks, institutions and materiality support the development and diffusion of the mission's solution, including the phase-out of harmful goods and practices?
- How does the mission arena align with existing (formal and informal) institutional structures related to the mission?

Structural analysis

- Entrepreneurial activities: Are experiments to develop existing and new solutions, conducted sufficiently rapid to complete the mission?
- Knowledge development: Is sufficient knowledge developed to understand the societal problem? Is knowledge to develop existing and new solutions, created sufficiently rapidly to complete the mission? Are actors sufficiently rapid unlearning practices harmful to the mission?
- Knowledge diffusion: is knowledge about the societal problem diffused sufficiently to formulate a broadly supported, clear, time-bound and ambitious mission? Is knowledge to develop and use solutions diffused sufficiently rapid amongst all stakeholders, to complete the mission?
- Problem directionality: How do stakeholders prioritize the mission's problem and framework conditions in relation to other societal problems?
- Solution directionality: Which stakeholders support and pursue the development and diffusion of the solutions sufficiently rapid to complete the mission? What solutions do they prioritize? Do stakeholders sufficiently recognize and exploit the interdependencies between different solutions?
- Reflexivity: Is the mission's progress monitored and is the MIS on track to meet the mission? If not, are sufficient measures taken to catch-up? Is the impact and relevance of MIP instruments regularly evaluated and, when needed, are they adequately redesigned? Does the mission still adequately capture a pressing societal problem? If not, is progress being made towards reorienting the mission?
- Market formation: Are formal or informal policies supporting the diffusion of solutions sufficiently rapid to complete the mission? Are formal or informal policies phasing-out harmful technologies and practices sufficiently rapid to complete the mission? Are stakeholders sufficiently rapid adopting the solutions? Are stakeholders sufficiently rapid abandoning harmful practices and technologies?
- Resources mobilization: Are sufficient human, financial and material resources mobilized to fulfil the other system functions?
- Creation of legitimacy: Do all stakeholders support the mission's problem? Are stakeholders advocating or lobbying to prioritize the mission's problem over other societal problems and wants? Are stakeholders advocating or lobbying for more solution-support and phase-out of harmful practices and technologies? What solutions receive the strongest lobby support or opposition?

This approach provides one way to systematize the dynamics of MOIPs by raising insightful questions, but faces a number of challenges. This includes a rather static perspective that may stand in contradiction to the temporal character of MOIPs, the neglected role of governance and coordination procedures, and the question to what extent the framework is capable of grasping the fundamentally different character of MOIPs. This in particular relates to the transformative character including social innovation and behavioral change that do not play a central role in the case study. Moreover, while the

definition of a mission arena contributes to conceptual clarity about the central actors, the overall boundaries of the MIS remain rather unclear.

3.2   Prospective & Adaptive Societal Challenges Assessment

One of the first approaches for the assessment of mission-oriented R&I programs was developed by Weber and Polt (2014) with the so-called PESCA approach - *Prospective & Adaptive Societal Challenges Assessment*. Two key insights are central for this framework: first of all Weber and Polt argue that the shift towards mission-orientation requires a different approach for the assessment, giving more importance to ex-ante evaluation. Secondly, they state that the impacts of missions are characterized by several connected stages at different levels. The initial impact of MOIP takes place at the micro-level of beneficiaries that – through diffusion processes – can potentially affect the systemic level which mission goals usually address. Consequently they emphasize the need for taking "systems of innovation, production and consumption" (Weber and Rohracher 2012) as a foundation.

Against the background of a growing importance of ex-ante evaluations they propose a novel, iterative framework (see figure 2). This strongly relies on scenario building and visioning as tools for investigating potential dynamics at different analytical levels. These are then brought together in a social cost-benefit analysis that prepares the ground for the realization and re-designing of policy interventions. In this regard, it is also important to emphasize that instruments are assumed to interact with each other, thus a comprehensive analysis should focus on the policy mix, instead of dealing with different instruments separately.

Figure 2:   Ex-ante assessment framework for mission-oriented R&I policies
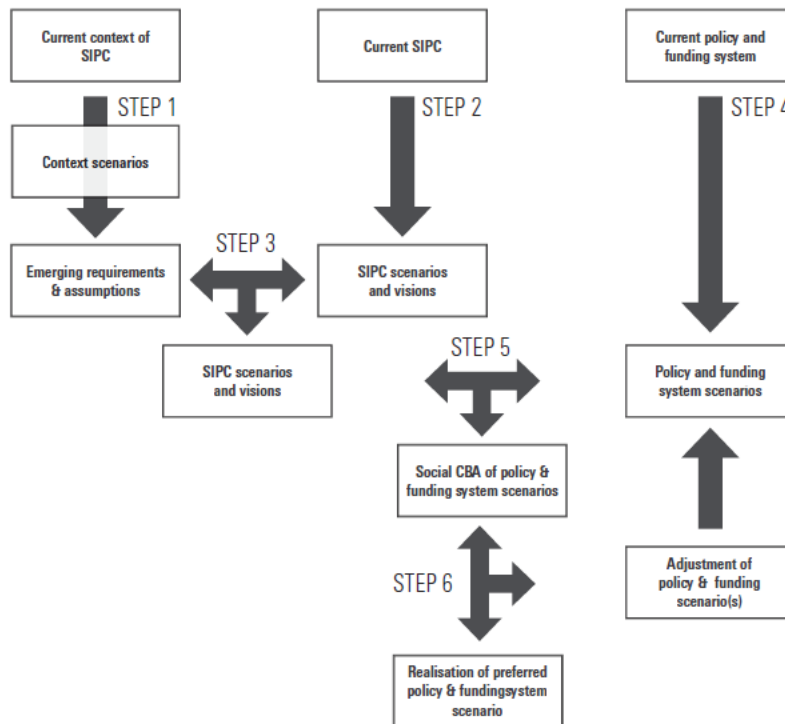
Source: Weber and Polt (2014, p. 8)

3.3   Evaluation of the German National Research Strategy Bioeconomy 2030

An attempt to evaluate a policy with explicit links to MOIP was provided by Fraunhofer ISI, focusing on the German research strategy in Bioeconomy (Hüsing et al. 2017). The study design relies on a multi-staged approach investigating this initiative both at the strategic and implementation level. For this purpose, the study combines a top-down perspective analyzing whether the design is appropriate for achieving the postulated goals with a bottom-up perspective of the project-level. This combination allows to compare expectations with actual policy implementations, accounting for the fact that there are multiple sources that may hamper the materialization of anticipated effects. A similar argument about transformative innovation policies has been also presented by Kroll (Kroll 2019), who emphasizes that translations between strategic agenda setting, thematic orientation and actual implementation may result in incoherencies that undermine the goals and create difficulties for evaluation.

Figure 3:   Design of Evaluation (in German)

Schaffung der methodisch-konzeptionellen Grundlagen

- Strukturierung des Evaluationsgegenstandes
- Analyse der einzubeziehenden Fördermaßnahmen
- Erstellung von Wirkungsmodellen und der Indikatoren zur Wirkungsmessung

Ex-post-Evaluation

Portfolioanalyse

Fragestellung:

Inwieweit sind die konzeptionelle Ausgestaltung der NFSB sowie ihre Umsetzung durch die zu evaluierenden Fördermaßnahmen geeignet, die gesellschaftlichen Ziele zu erreichen, auf die die NFSB ausgerichtet ist?

Datenquellen:

- Programmdokumente und -kenndaten
- Angaben von Geförderten aus der Online-Befragung
- Angaben von Experten aus der Stakeholder-Befragung
- Studien zu Strategien von 5 Vergleichsländern

Wirkungsanalyse

Fragestellung:

Wie sind Zielerreichung, Wirksamkeit und Wirtschaftlichkeit der Fördermaßnahmen und der darin geförderten Projekte zu bewerten? Wie sehen Wirkungsgefüge und Einflussfaktoren auf die Zielerreichung und Wirksamkeit aus?

Datenquellen:

- Online-Befragung der Geförderten (Totalerhebung unter knapp 1.800 geförderten Projekten mit Bewilligung von 5/2009 bis 1/2016)
- Interviews und Dokumentenanalysen für Fallstudien zu 18 Projekten
- Beobachtende Teilnahme, Interviews und Dokumentenanalysen zur Initiative *Nächste Generation biotechnologischer Verfahren – Biotechnologie 2020+*

Ex-ante-Evaluation

Empfehlungen zur Weiterentwicklung der Strategie

Fragestellung:

Wie sollen die konzeptionell-inhaltliche Weiterentwicklung der Bioökonomie-Forschungsstrategie, ihre Umsetzung in Fördermaßnahmen, die Ausgestaltung konkreter Fördermaßnahmen sowie die Ausgestaltung künftiger Evaluationen der Bioökonomie-Forschungsförderung aussehen?

Datenquellen:

- Online-Befragung von Stakeholdern in unterschiedlichen Fachdisziplinen und Institutionen
- Online-Befragung der Geförderten

Schlussfolgerungen und Empfehlungen

- Zusammenführung der 3 Untersuchungsbereiche
- Spiegelung an Experteneinschätzungen auf einem Validierungsworkshop
- Feedback bei der Abschlusspräsentation

Source: Hüsing et al. (2017, p. 7)

Hüsing et al. (2017) rely on a multi-method approach to approach these questions. A portfolio analysis explores how strategic goals were translated in specific funding instruments and explores the thematic priorities of projects and relations between different projects, investigating budget sizes, TRL levels involved etc. The results feed into an analysis of the effects of these funding schemes, asking about mobilization, outputs and effects on research activities. Finally, in order to derive recommendations of the future design of the strategy, they carry out an ex-ante evaluation based on a survey among relevant stakeholders (beneficiaries and non-beneficiaries) and expert interviews in order to develop recommendations.

However, it needs to be kept in mind that the analysis focuses on the evaluation of a single strategy referring to the principles of mission-orientation. Depending on the problem addressed, the range of instruments and impacts might be broader. Moreover, the

approach departs from a defined set of actors and interventions. In contrast, in many instances, when analyzing MOIP it is first necessary to delineate the boundaries.

3.4   WIFAS - System zur Wirkungsfolgenabschätzung missionsorientierter Forschungsförderprogramme

Another recent approach for grasping impacts of mission-oriented research and innovation programs is the Austrian project entitled WIFAS. It strives for developing a model for assessing the societal impacts in the mobility sector that only received limited attention in the past (Kaufmann et al. 2015). The authors claim – that despite the focus of this study on the mobility sector – the key principles can be translated to different areas as well.

In a first step and building on an extensive literature review and expert interviews, the authors develop a framework for specific impact dimensions of projects in the mobility sector, trying to delineate three main dimensions: economic, ecological and social impacts (impacts on society/health/socio-economic effects).[6] Aiming to incorporate the importance of distributive effects in the mobility sector, the authors moreover argue that these types of impact can vary along three cross-cutting dimensions: socio-demographic characteristics, spatial characteristics (agglomeration – periphery), and temporal differences (see figure 4).

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[6]   The authors emphasize that in many instances social impacts were commonly seen from an economic perspective (similar also Amanatidou et al. (2014, p. 432).

Figure 4:   Impacts of mobility (in German)
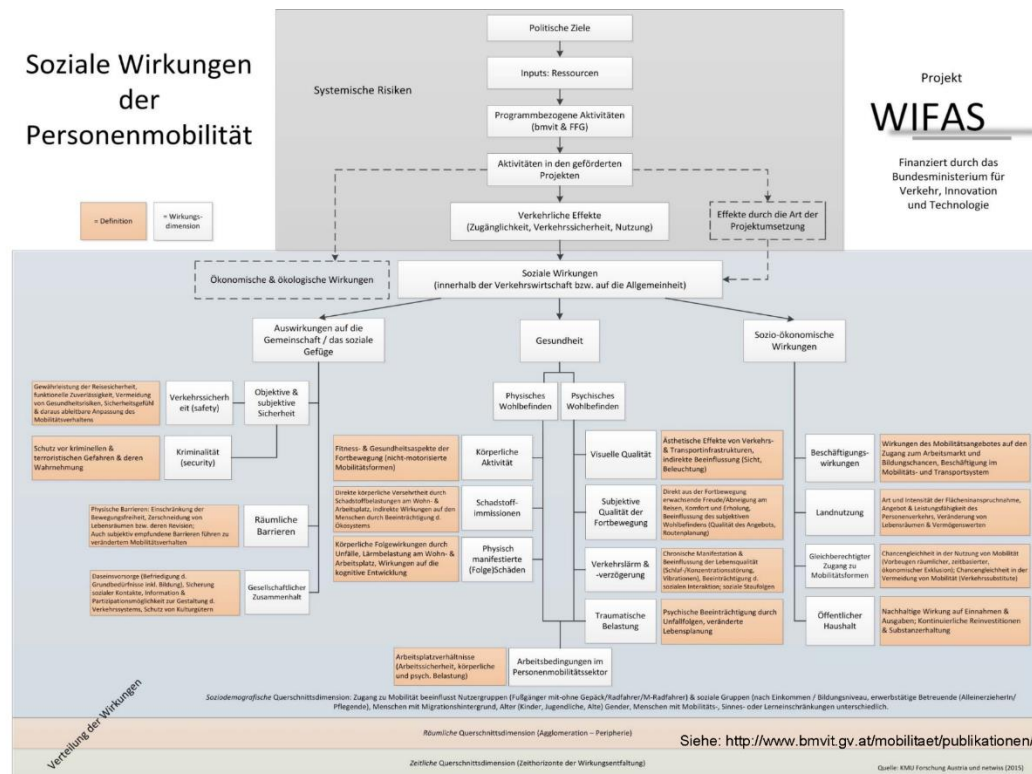
Source: Kaufmann et al. (2016, p. 16)

The developed frameworks were tested empirically by investigating past and current projects by a standardized survey. The approach takes the guidelines of the European Commission for impact assessment (European Commission 2009, 2015) into account, to identify impacts first and study the most relevant of them at a later stage through qualitative and quantitative analysis. Quantitative indicators mainly gain importance at an ex-post perspective at the project level and the programming level, whereas qualitative indicators can be applied at all stages of the evaluation (Kaufmann et al. 2015, p. 68).

The paper describes a way of identification and analysis of complex societal impacts in a thematic area, but does not provide a comprehensive framework for analyzing MOIP. While the authors acknowledge that there might exist trade-offs and tensions between impact dimensions (Kaufmann et al. 2015, p. 71), the framework itself does not provide ex-ante expectation management about the possible interaction of different effects. Therefore, the literature-based approach might be particularly promising for those cases that are backed by a sufficient number of studies. A second challenge that can be seen from the document relates to the translation of problems into specific programs or projects. On the one hand, the empirical analysis of programs in different countries by the authors (ibid., pp.41-46) reveals that the emphasis on non-economic/non-ecological aspects varies across countries. In a similar vein, the authors highlight that the expert sur-

vey revealed a core challenges: how to deal with different project specifications and varying levels of ambition and outreach (ibid., p. 79) – this ties in with the aspect of internal diversity among missions (see discussion above).

3.5　　　　A challenge-driven framework

Grillitsch et al. (2019) present a more abstract framework that departs from the specific challenges of transformative innovation policies. It acknowledges the demands of Walz (2016) who emphasized the need for a greater focus on processes instead of inputs/outputs alone to understand MOIPs. Building on the characteristics of transformative innovation policies the authors outline four domains for potential challenges:

i. directionality

ii. experimentation,

iii. demand articulation,

iv. policy learning and coordination.

For each of these dimensions, they further differentiate between challenges for key elements of the innovation system (actors, their interests and capability/networks/institutions) to outline specific challenges against which the empirical case can be assessed. Empirical assessment was carried out via expert interviews making use of a combination of open question and structured interviews refereeing to theoretically identified challenges in order to obtain a comprehensive picture.

The challenge-driven approach has the advantage that it provides a generalizable approach that is non-case specific and therefore can be applied to a wide range of empirical cases. At the same time, the framework rests on the assumption that challenges generally should be similar across different types of MOIPs. However, as argued in section 2, there is a wide variety of MOIPs with several policies rather resembling "traditional" mission orientation. Moreover, the perspective of the framework rests on a meta-level, thus does not yield insights into the role and interplay of different instruments or the systemic impacts of the individual MOIP under study.

Table 2:　　Overview evaluation/impact assessment literature with MOIP focus

Concept (Authors)	Core concept	Component(s)	Limitations
(Technological) Innovation system approaches (Janssen 2016; Hekkert et al. 2020; Wesseling and Meijerhof 2020)	Focus on specific functions that are key for realization of mission, based on (technological) innovation system approach (TIS).	TIS-based framework of key functions	Capturing transformative character including behavioral change Static perspective

Concept (Authors)	Core concept	Component(s)	Limitations
	Mission-oriented innovation system approach (MIS) that extends TIS approach		
Prospective & Adaptive Societal Challenges Assessment (Weber and Polt 2014)	Translation process of impacts across different levels (impact pathways) Increased importance of ex-ante evaluations resulting from the shift towards mission-oriented policies	Ex-ante framework drawing on scenarios/visioning and social cost-benefit analysis	Limited focus on instruments beyond R&I policies
Evaluation of the German National Research Strategy Bio-Economy 2030 (Hüsing et al. 2017)	Combination of analysis at different levels (strategic, program level, projects) with combination of top-down/bottom-up perspective Importance of translation processes (cf. also Kroll 2019)	Portfolio-Analysis, Survey on beneficiaries of programs and other stakeholders (ex-ante/ex-post) & expert interviews	Scope (research funding, defined intervention) narrower than many MOIPs
WIFAS (Kaufmann et al. 2016)	Literature review for identification of key areas of impact that can be studied by standardized surveys	Verification of template based on standardized survey	Dependency on literature on topic Existence of interaction effects Perception-based success indicators
Grillitsch et al. (2019)	Focus on challenges in main domains of transformative policies and for key aspects of innovation system	Case study on strategic innovation programs of Vinnova (Sweden)	Empirical diversity of missions Project-level is not part of focus Perception-based success indicators

4   Selected insights and approaches from the broader impact assessment literature

As argued in the previous section, there is no established and commonly accepted template for evaluating the impact of MOIP yet. At the same time, there is a growing number of evaluation approaches in fields beyond MOIP that face similar challenges. While a comprehensive review is beyond the scope of this paper, in this second part of this document, we discuss approaches that can be considered as particularly useful to address some of the potential challenges and thus might contribute to develop a comprehensive framework for impact assessment in case of MOIPs.

4.1   Capturing complex developments and policies at different levels

A key problem for the evaluation of MOIP is their complexity with regard to the underlying dynamics that in many cases run across different analytical levels. Many evaluation researchers have argued for the use of a theory-based approach, developing intervention logic/impact pathway models that allow to contrast developments with theoretical expectations (Joly et al. 2015; Miedzinski et al. 2013; Arnold 2019; Joly and Matt 2017; Bührer et al. 2019; Kalpazidou Schmidt et al. 2017; Joly et al. 2019; Arnold et al. 2018). This section provides an overview on some of these approaches and explores the way they describe the complex effects in their respective investigations.

4.1.1   ASIRPA: the impact of research organizations

A recent example of research impact assessment is the so-called ASIRPA approach which was developed by the French National Agricultural Research Institute (INRA) in order to investigate to societal impacts of its work, constituting a reaction to the increasing focus on impacts beyond the economic dimension (Joly et al. 2015). It builds on insights of previous literature for research impact assessment, including public value mapping (Bozeman and Sarewitz 2011; Bozeman 2003), the payback framework (Donovan 2011), SIAMPI (Spaapen and van Drooge 2011), and impact pathways (Douthwaite et al. 2003; Kuby 1999).[7] Thereby, it aims for enabling both accountability and internal learning and seeks to flesh out the process of transformation of knowledge into use.

It is carried out by the use of standardized case studies and consists of three main analytical tools to unravel the impacts:

i.   a chronology of main events and relevant turning points to avoid an incorrect attribution of impacts,

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7   For an comprehensive overview see Matt et al. (2017, pp. 208–209).

ii. a graphical impact pathway to capture the multiple (non-linear) translation processes from knowledge to impact,

iii. the construction of vectors of impact for relevant dimensions that allow a (visual) comparison of impacts across different cases and dimensions.

This approach provides a number of advanced elements that can contribute to a study of the impact of the German Hightech Strategy 2025. Firstly, the reliance of standardized case studies has the potential for a systematic comparison of impacts in different missions and therefore provides the possibility for outlining a general but flexible framework for future use. On the other hand, it has the potential to capture impact as a multidimensional, multi-level, network-driven and non-linear phenomena (Joly et al. 2015, p. 444) that can be expected to prevail in case of MOIPs.

However, the short time horizon of the HTF might be a challenge: relying primarily on an ex-post assessment (ibid., p. 441), especially the chronology of impact might be insufficient to capture the dynamics in a policy strategy that is only at the very beginning of its realization. This problem appears even more serious as cases were selected based on the dependent variable (successful outcome), thus ignore the fact that not all policies necessarily bring the anticipated/desired effects in the time period under investigation/at all. Therefore, one challenge requiring further conceptual reflection would be to map non-successes or failures wherever necessary. However, there are currently attempts to create a real time-based approach for ASIRPA building upon an iterative process and step-by-step evaluation (Joly et al. 2019).

Moreover, Matt et al. (2017) provide four ideal-type pathways based on their impact assessment, which can provide useful insights into relevant dynamics:

i. Intensive transformation based on existing networks: short research period, large network of actors, orchestration of diffusion by INRA, high/quick impacts,

ii. strong collaboration in long-term research programs: long-term risky research projects, joint co-production of knowledge, high impacts but long-time perspective,

iii. market for technologies: INRA-based research, few networks, (low) economic impact,

iv. public research as key initiator of intensive transformation: rather long research period, public networks, demand failures, INRA involved in diffusion, (low) political impacts.

4.1.2   RI PATHS

The EU-funded RI PATHS (Research Infrastructures imPact Assessment paTHwayS) project provides a comprehensive toolkit to showcase the socio-economic impact of research infrastructures (Griniece et al. 2020). It rests on the idea of identifying different impact pathways that link the institutional activities to expected outcomes in different areas. By providing a narrative for the sequence of activities it traces the development

along these pathways by three types of indicators that reflect the varying degree of control:

- Activity indicators (direct control),
- outcome indicators (potential influence),
- impact indicators (target dimension).

Figure 5:   Spheres of influence and elements for impact pathways
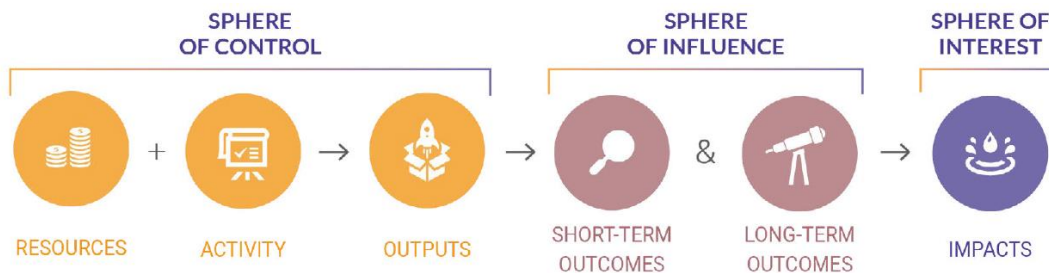
Source: Griniece et al. (2020, p. 6)

A modular approach (toolkit) is suggested by Ri-Paths, which has to be adjusted to each specific case, where the identified pathways (e.g. P1 Publication-citation-recognition) serve a specific function (e.g. enabling science) and influence generic impact areas (e.g. society, human resources).

The toolkit comes along with a questionnaire to allow research institutions to develop the assessment in a top-down (starting from questionnaire) or bottom-up (going via existing data and indicators) way and provide guidance on possibilities on how to assess impact (Helman et al. 2020, p. 26). The project identified 13 specific impact pathways that are grouped in overarching categories (enabling science, problem-solving, science and society). The approach is methodologically open: instead of focusing on a specific methodological approach, it seeks to provide a foundation for tracing the pathway towards impact over time, suggesting to rely on adequate choice of methods that allow for gathering and interpreting the required information.

This approach provides multiple valuable insights for measuring the impact of MOIPs. First of all, its method to identify different pathways towards anticipated impacts appears highly suitable for MOIPs. Given the complex and multifaceted character of missions, in many cases there might be simultaneous strands of activity necessary to achieve the desired outcomes. The idea of disentangling different logical chains and their specific indicators may help to decompose missions into their individual parts. Secondly, developed for research institutions, the flexible toolbox approach can serve as a template to transfer the concept to a more complex and multi-faceted actor – the government in charge of implementing an explicit mission-oriented approach. Thirdly, the participatory inductive approach may closely align with the need for a formative evaluation concept that involves stakeholders.

Among possible problems with regard to a framework for impact assessment of MOIP there are particularly two aspects that require further clarification. On the one hand, the concept postulates the existence of multiple pathways that exist next to each other. A key question in this context remains, to what context there might exist interactions between different strands, imposing either reinforcing/limiting or sequential relationships. While acknowledging that there might be interactions between pathways, the framework does not provide any guidance on the specification of these interaction. The broader character of missions might increase the need to account for such dynamics and complexities. On the other hand, the MOIPs in many instances reach beyond pure STI policies. While the same applies to the activities of research institutions, the problem that the realization of certain aspects lies beyond the scope of control of the mission-owner might be considerably larger. This could apply e.g. to regulatory aspects that shape the overall context and are conditional for the realization of a pathway. While the distinction between different degrees of control are helpful in this regard, a more systematic approach for understanding what context factors are key might be necessary when studying missions.

4.1.3   Multi-level impact assessment

Miedzinski et al. (2013) develop a framework that allows to assess the scope and environmental impact for research and innovation policies, thus addressing the problem of how to incorporate different levels of analysis into evaluation and studying direct and indirect impacts (at micro-/meso-/macro-level). At the heart of this framework is an extended understanding that focuses on both the research/innovation system and the ecosystem and has the qualitative mapping of (potential) impact pathways at its core. Thereby it rests on the idea that impacts are not only affected through context conditions (determinants of research & innovation/state of the environment) but also that the realization of environmental impacts is "filtered" through the dimension of socio-economic impacts.

Its five dimensions, consisting in turn of sub-dimensions that can be used to map the pathways visually in an impact assessment canvas, demonstrating how inputs relate to impacts and identifying cumulative effects of different pathways:

i. research and innovation policy mix: the instruments available,
ii. outputs and outcomes of R&I policy: new/modified knowledge; new/modified behavior and forms of organizations; new/modified products, technologies and infrastructures,
iii. socio-economic impacts of R&I policy: knowledge generation and learning systems; policy regulation and governance systems, social practice and consumption patterns, production system and business models, technical infrastructures and built environment,
iv. environmental pressures,
v. environmental impacts.

Figure 6:   Visualization of multi-level impact assessment framework
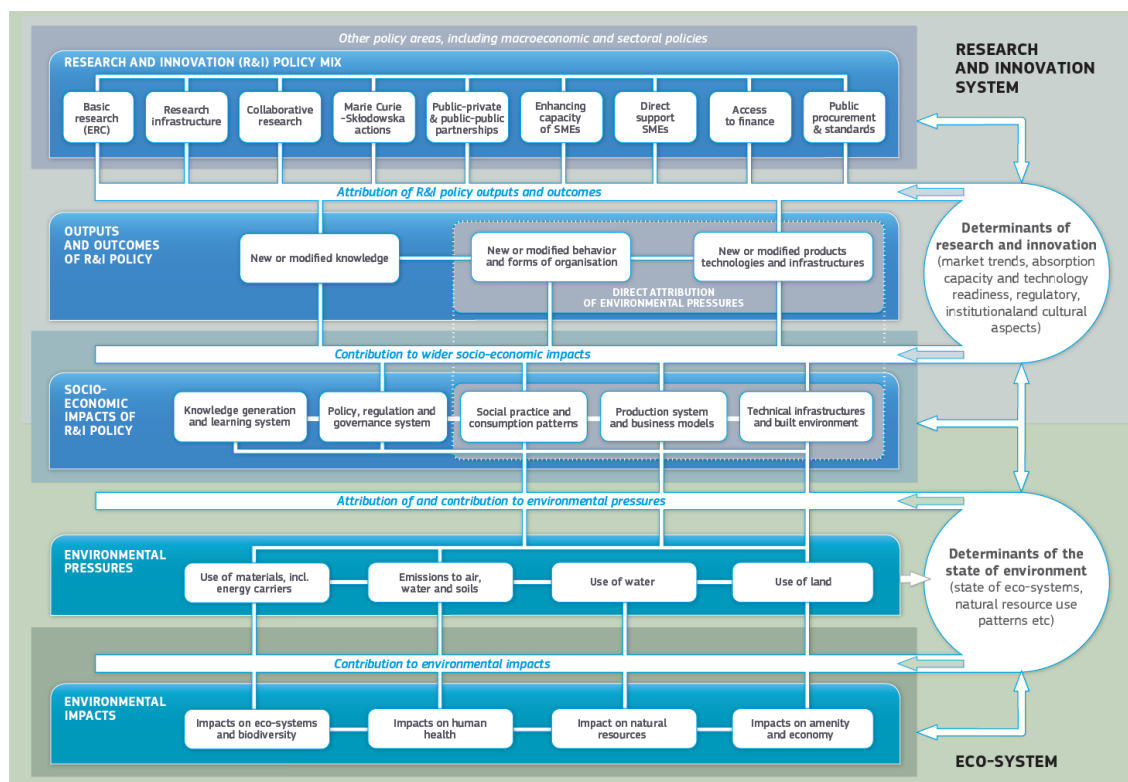
Source: Miedzinski et al. (2013, p. 12)

This approach introduces the idea of certain types of impacts being affected through changes in different levels, using impact pathways to map their flow through the canvas. The canvas also can be used for mapping the pathways of different instruments/inputs simultaneously, to gain insights about potential interactions between these instruments. For the context of MOIP, however, it leads to the question how different impact dimensions are connected with each other – as missions may seek to mobilize dynamics in different areas in order to address societal challenges.

4.1.4   EFFORTI: Evaluation Framework for Promoting Gender Equality in Research and Innovation

The EFFORTI Framework provides useful insights into the development of a holistic theoretical and practical framework for the evaluation of (gender equality) measures and policies on different levels, i.e. on the individual, structural/institutional, legislative and research-funding-related level (Bührer et al. 2019). It offers valuable entry points and guidance for the development of a new conceptual framework that embraces the complex dynamics and contextual embeddedness of impacts, their non-linear and asynchronous emergence and development and questions of causality – all main features inherent to the new mission-orientation and the question of their assessment as well.

The framework was created by an international consortium in the context of the Horizon 2020 project EFFORTI (Evaluation framework for promoting gender equality in research and innovation, 2016-2019), coordinated by Fraunhofer ISI. Guided by the overarching goals to increase the number of women in R&D in leadership positions and to promote the integration of a gender dimension in research content and curricula, the framework supports policy-makers, researchers and R&I stakeholders to model and assess gender equality interventions on R&I.

It draws on a theory-guided approach and intervention logics. While the theory-guided approach can be helpful in establishing linkages between interventions and observed effects, the intervention logic models serve to sketch an ideal type effect theory of an intervention to help examine how a specific intervention *may* contribute to a goal and envisaged impact (Kalpazidou Schmidt and Graversen 2020). More precisely, the methodological approach starts form a desk research of relevant indicators which are then systematized and grouped into a logic model based on existing literature. The intervention logic follows an I-O-O-I logic, i.e. inputs, outputs, outcomes and impacts, which are further differentiated between the micro, meso and macro level (see figure 7).

Figure 7:   Intervention logic model for a selected intervention (targeted funding) from the EFFORTI Project
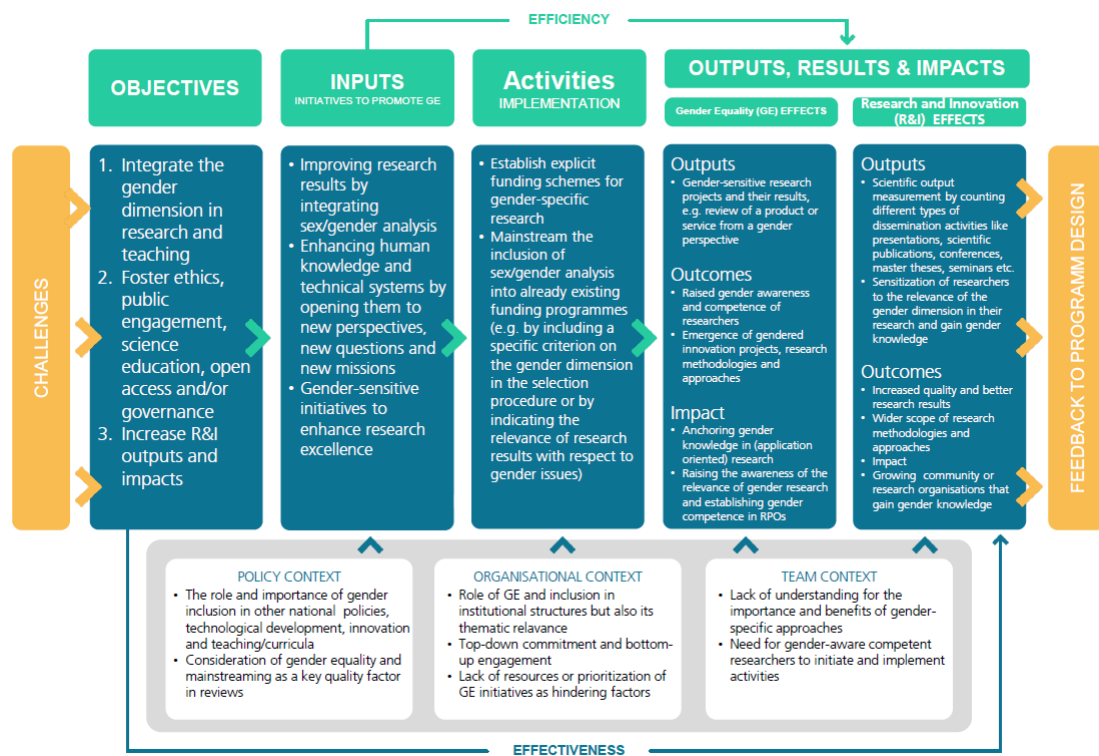
Source: Bührer et al. (2019, p. 142)

The theory driven approach allows to select the variables to be assessed according to a theory that formulates implicit or explicit assumptions about the interventions and the

features expected to be important for achieving impact (Chen 2012). By seeking to explain the linkages between interventions, outcomes and impact with the help of context-sensitive logic models, EFFORTI extends the limited scope of impact-oriented evaluation models that focus solely on the question of *whether* an intervention has achieved an intended impact - a binary and narrow lens on deciphering effects/effect pathways which is not useful for an investigation of the impacts of MOIPs in the HTF context.

The complexity approach adopted in the EFFORTI framework (Kalpazidou Schmidt and Graversen 2020) helps understand interventions - similar to missions- as embedded in multilayered, dynamic and non-stable systems in which numerous variables and factors interact in very different ways, resulting in manifold interactions and impacts. It is no surprise that within these complex dynamics, establishing meaningful causal links between interventions and impacts (= deterministic attributions) is hardly possible (Kalpazidou Schmidt and Cacace 2017).

In fact, the peculiarity of this framework is precisely that, rather than intending to provide a proof of causality (direct attribution), it focuses on the mechanisms (the *how*) and the actors (the *who*) of the effects by also placing special emphasis on the context and *conditions* in which effects unfold and develop. Yet, while this approach enables to dissect and de-complexity processes, its drawback is the risk of overemphasizing expectations and assumptions (Bührer et al. 2019, p. 144) and that the mentioned simplification literally means a simplification and idealization of 'reality'.

In sum, irrespective of the particular focus on gender equality interventions, EFFORTI provides valuable transferable insights and learnings for HTF. The first one resides in the framework's "differentiated approach' that seeks to account for different policy measures and contexts, such closely resembling the setting of MOIP where one should expect a mix of policy instruments and mission-specific settings. Moreover, by highlighting the insufficiency of linear, causality-based models to capture the complex nature of impact assessment, it makes a strong claim for developing a holistic and context-sensitive framework that focuses on the mechanisms and conditions of selected missions in which policy measures and interventions induce change and accumulate to impacts.

4.1.5   FONA Evaluation

The evaluation of the research framework programs focused on sustainability (FONA) that was led by Fraunhofer ISI (Bührer et al. 2020) reveals a number of parallels with MOIPs. What makes this work particularly interesting is the fact - that similar to MOIPs - there is a simultaneous existence of multiple goals and measures, such as research funding and infrastructure investments, as well as an interdisciplinary and systemic approach including a wide range of stakeholders.

Besides the richness in data and the methods triangulation (online-survey, interviews, case studies, focus groups, bibliometrics, document analysis, analysis of database for research funding) that aims to provide an understanding beyond the impacts of science itself, especially the reflections on the impacts at different levels are helpful to better grasp the multi-level and multidimensional character of MOIPs. Advocating a theory-based evaluation approach, the authors distinguish between interdependent impacts at the micro- (beneficiaries of funding), meso- (involved institutions/domains like research), and macro-level (systemic level of economy, society, etc.). Figure 8 displays the interde-pendency between different levels and highlights the contribution of micro and meso level to systemic impacts. Methods for data collection differ according to the level ranging from bibliometrics and online-surveys at the project level, over case studies with inter-views and document analysis for selected instruments and focus group discussions and expert interviews at the program level. The authors themselves conclude that against the background of mission-oriented policy programs two features are essential for analysis: context-sensitivity and a methodological pluralism combining different sources of data (Bührer et al. 2020, p. 135).

Figure 8:   Levels of impacts in the FONA evaluation
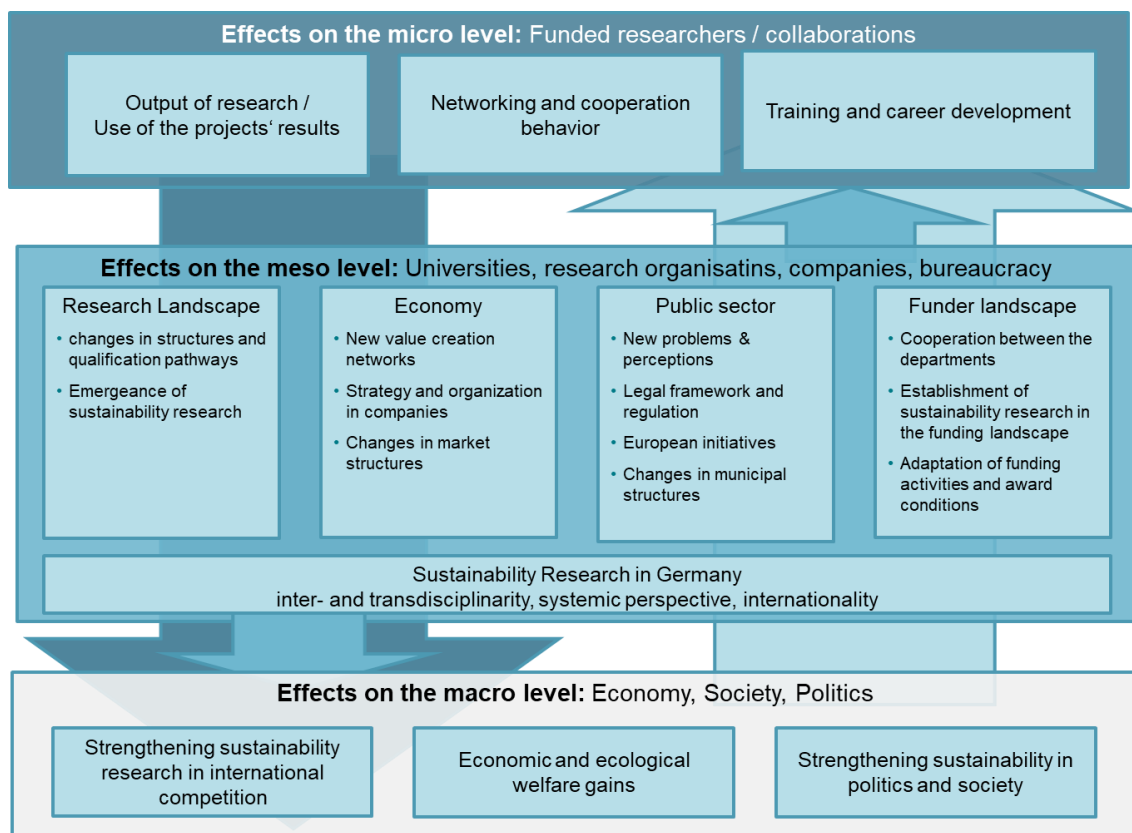
Source: Bührer et al. (2020, p. 7)

4.2   Policy mixes

4.2.1   Towards a concept of policy mixes for MOIP?

Another challenge related to the diversity of potential impacts and interconnected of dynamics is the diversity of missions at the instrument level. Whereas there have been different attempts to classify the different character and type of instruments in literature (Howlett et al. 2015; Hufnagl 2010; Rogge and Reichardt 2016), the complexity implies that missions are more than the sum of their individual components and thus are defined by the interplay of the different instruments. However, despite growing interest in the topic in the context of innovation policy (Flanagan et al. 2011; Edler et al. 2008) its implications for implementation and evaluation are not fully explored yet (Magro and Wilson 2013, p. 1648).[8] This even more applies to the concept of MOIP. The reference to an instrument or policy mix has been popular in the literature dealing with MOIP (Janssen et al. 2020; Wesseling and Meijerhof 2020; Hekkert et al. 2020; Amanatidou et al. 2014). However, as Larrue (2021, p. 63) notes the character of policy mixes is more narrow, compared than many understandings of policy mixes (cf. Rogge and Reichardt 2016) that comprise instruments, but also processes (policy-making) and policy strategies.[9] Consequently, the focus regarding MOIP might by mainly to the instruments and particularly the analysis of their characteristics where Rogge and Reichardt (2016) distinguish the following analytical dimensions: consistence of elements, credibility, comprehensiveness, coherence of processes.

4.2.2   Combining complexity and policy mixes

A recent contribution aiming to combine multi-dimensionality of domains, actors and impacts has been proposed by Magro and Wilson (2013, 2019). Their approach of an evaluation mix aims to address the challenges arising for innovation policies from multi-level structures, complex governance arrangements and smart specialization approaches. The publication from 2019 focuses on the consequences of new governance modes to the core question an evaluation aims to address. In their 2013 paper however, Magro and Wilson outline a framework for carrying out evaluation when facing policy mixes - an "evaluation mix protocol". This consists of the following six steps, with steps 3-5 have to be carried out for each rationale separately:

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[8]   Cf. also the distinction by Cunningham et al. (2016) between the analysis of innovation policy mixes between target groups and approaches with a systemic approach.

[9]   Recent works in the field have focused on questions of policy mixes for sustainability transitions, the role of destabilization policies and different intervention points Edmondson et al. (2018); Rogge et al. (2020); Kanger et al. (2020).

- Drawing the policy and establishment of boundaries for rationales, domains and instruments (policy mix) and institutional responsibility (multi-level),

- selection of policy rationale,

- analyzing the mix of domains/instruments at different levels to identify overlaps and complementarities,

- assessment of current evaluation practices against the background to which extent the account for interactions between instruments,

- development and implementation of integrated evaluation for each rationale, including instruments,

- combination of different evaluation along rationales into comprehensive evaluation (evaluation mix).

This approach resembles a bottom-up perspective described by Ossenbrink et al. (2019) approaching the mixes of policies through a thematic orientation. This stands in contrast to the purposefully designed mix of instruments for MOIP (Larrue 2021) and might be at odds with the directionality of missions that define specific goals. While providing a systematic overview, the distinction between the core of a mission and the wider socio-technical system (Wittmann et al. 2020b; Wesseling and Meijerhof 2020) remains a challenge. Moreover, while allowing to decompose the complexity by differentiating between rationales, the question remains to what extent interaction between different areas will be captured (cf. Miedzinski et al. 2013), as interactions might occur at different levels and in different ways. Treating rationales as closed entities that are only combined at a final stage might overlook that e.g. outputs (and not impacts) at one level might be of importance for another strand.

4.3   Long-term effects and measurement and impacts

Another challenge related to the measurement of impacts of MOIP is the long-term perspective for the realization. This problem is not only specific for MOIP and existing evaluations have developed different attempts for grasping effects at an earlier stage. The subsequent section discusses relevant approaches in these areas.

4.3.1   Productive interactions

One of the key challenges in impact assessment in general and mission-oriented innovations in particular is the long period until effects materialize, making it difficult to attribute causality to a certain factor. The SIAMPI project, which is rooted in the research strand of knowledge exchange (e.g. Bozeman and Sarewitz 2011; Donovan and Hanney 2011), addresses the problem of slow materialization of impacts for the area of science by tracing the flow of information between researchers and other stakeholders und revealing the uptake of information (Spaapen and van Drooge 2011; Spaapen et al. n.d.;

Jong et al. 2014).[10] By focusing on the process instead of the actual impact, these "productive interactions" between actors can serve as a sign for early impact or the potential for future impacts.

The authors distinguish three main types of productive interactions:

i) direct interactions (e.g. personal exchange),
ii) indirect interactions through a medium (e.g. via publications),
iii) financial interactions or material exchanges (e.g. research funding).

As can be seen from table 3 below, the kind of data used for assessments varies depending on the type of interaction. Moreover, it is worth noting that multiple interactions can take place simultaneously, such as personal and indirect exchange. This approach might be a valuable tool for exploring early signs of potential impact and thus mitigate the problems of later materialization of effects. However, there are also several obstacles that need to be kept in mind. First of all, the concept is rooted in the translation process of science into application. MOIP however, are not necessarily only technology-driven and thus might have a varying starting point. Therefore, the concept of productive interactions might have difficulties e.g. to capture other dynamics such as regulatory changes and their specific impact. Secondly, in line with Bozeman and Sarewitz (2011) one needs to be aware that e.g. the focus on bibliometric data might be limited as it does not yet provide an impression e.g. about the quality and size of an impact. Finally, the knowledge production process is assessed according to the needs of final users instead of program goals (Feidenheimer et al. 2019, p. 29) – a fact that might require adjustment when taking a closer look at the impact of MOIPs.

Table 3:   Types of productive interactions

Productive Interactions	Social impact	Stakeholder	Assessment tool
Direct, personal	Behavioral change	One-to-one, personal and professional networks	Interviews, focus group
Indirect, media	Uptake, use	Different audiences	Quantitative data collection
Financial or in kind support	Collaboration	Joint projects	Annual reports, other documents

Source: (Spaapen et al. n.d., p. 2)

Recent work has aimed to link these productive interactions more closely to causal pathways (Muhonen et al. 2019). In their paper on the social impact of social sciences and humanities, the authors argue that the impact can vary considerably, ranging from new products, to new methods and new perspectives. In this context they identify 12 pathways for societal impact that can be subsumed to four main strands: dissemination, co-

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10   See also the project Evaluating Research in Context (ERiC 2010).

creation, reacting to societal change, and driving societal change. While these insights might be domain-specific, they illustrate that productive interactions are embedded in a context and require an understanding of the underlying pathways to fully grasp the impacts.

4.3.2   PVM: Public Value Mapping

An alternative approach is developed by Bozeman and Sarewitz (2003; 2011) with their framework of Public Value Mapping (PVM). Whereas the SIAMPI approach of productive interactions focuses on the need of end users in knowledge production, the PVM is more closely linked to the decision-making process and its alignment with public values (Feidenheimer et al. 2019, p. 29) . Thereby it is considered to serve as both an evaluation tool and as a toolbox for policy-making. Since they want to look beyond economic effects, the authors argue that the key for evaluating programs and policies is to assess the underlying public values and the degree of achievement. Their approach consists of multiple steps (Bozeman and Sarewitz 2011, pp. 17–19):

i) Identification of public values, by making use of diverse sources (official documents, academic literatures, public statements and opinion polls),

ii) application of the PVM criteria in order to identify failures in achieving those aforementioned values, such as mechanisms for value articulation and aggregation, time horizon, concentration. While providing a list of criteria, the authors encourage researchers to adjust these categories wherever necessary,

iii) clarification of the relationship between different values and evaluation how these influence the impacts of research on anticipated outcomes,

iv) locating cases along the axes of market failure/market success vs. public failure/success.

As the authors point out (Bozeman and Sarewitz 2011, p. 18), especially the third step constitutes a challenge as existing research did not yet provide a comprehensive answer how to map the interrelationship between the values appropriately. The contribution to the underlying preferences and priorities, however, can be a useful tool to better understand the development of MOIP over time. Even more pronounced is this element in the more process-oriented approach for analyzing policies as outlined by Alford and Yates (2014). Here, the authors suggest that after identifying public values and the desired outcomes, the analysis should delineate the core processes, the associated actions and relevant actors.

5 Towards a framework for Impact Assessment of MOIPs

As part of the scientific support action to the German Hightech Strategy 2025, this report prepared the ground for a framework for impact assessment of MOIPs. First of all, it highlighted the specific challenges for impact assessment and evaluation emerging from the shift towards a mission-oriented approach (section 2). Subsequently, it summarized those existing approaches that explicitly link to mission-oriented policies (chapter 3), taking a broader look to approaches dealing with similar challenges in chapter 4.

This overview demonstrated that MOIPs create a series of challenges for the evaluation of policies and their impacts. In this context, chapter 2 identified the following key challenges that should be taken into consideration:

- Breadth of scope for analysis and multi-dimensionality of impacts Interconnectedness of dynamics and impacts,
- long-term materialization of impacts,
- existence of multiple levels of analysis,
- new motivations and guiding questions,
- empirical diversity of missions and varying interpretations of mission-orientation.

Subsequently, this report provided an overview on existing approaches of impact assessment and evaluation for MOIP, and discussed other potentially promising approaches that yield insights on how to address the aforementioned challenges. Drawing on the insights, the remainder of this section summarizes the key insights of this stock-taking that can guide the way for the development of a framework of impact assessment of MOIP (see figure 9).

Figure 9: Key Insights from the overview

1	Making use of a theory-based approach to capture the complexity of dynamics
2	Combining formative and summative elements to allow for a support of implementation, enabling learning processes while allowing to track the progress of the mission
3	Clarifying impact dimensions and their relationship with each other
4	Including a process-oriented perspective that accounts for the requirements of transformative policy-making
5	Taking into consideration the different stages and dynamics of such policies, resulting in a mix of methods and tools to comprehensively assess its potential impacts

Firstly, several approaches (Joly et al. 2015; Miedzinski et al. 2013; Arnold 2019; Joly and Matt 2017; Bührer et al. 2019; Kalpazidou Schmidt et al. 2017; Joly et al. 2019; Arnold et al. 2018) have made a strong claim for the **use of a theory-based approach** that allows to contrast actual developments with theoretical expectations. **A core element of many of these approaches is the development of impact pathways, describing the link between inputs and the anticipated impacts.** Among the key advantages of these approaches is the possibility to combine impacts on different dimensions, the disentangling of complex dynamics by decomposing missions into different strands of activities, and the possibility to cope with the long time lag between policies and the materialization of effects. When focusing on pathways, it is possible to derive indicators along the pathway to see whether a mission is "on track" or provide both an ex-post or ex-ante evaluation. In this regard, these approaches can also be usefully employed to support the implementation process.

This ties in with a general shift in the field based on the understanding that transformative policies should be accompanied by an evaluation approach that facilitates learning processes (Amanatidou et al. 2014; similar Magro and Wilson 2019) – as learning itself can be understood as "a key feature of transformation processes".[11] However, **complex programs should not abandon summative components altogether, but rather strive for integrating both formative and summative elements in their framework** (Amanatidou et al. 2014; Arnold et al. 2018). **Consequently, a framework for MOIP should be both helpful to investigate the impacts of a policy while supporting the implementation process.**

A key challenge in this regard remains the question how and at which levels different dynamics are interacting with each other, in particular as impacts in one area might be conditional for other impacts (Miedzinski et al. 2013).[12] **Consequently, it is necessary**

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[11]   Cf. also Rotmans et al. (2001); Loorbach (2007); Schot and Geels (2008). Learning is supposed to take place at different levels: at the operational level for enhancing the policy intervention, at the policy level to improve the design of future interventions and testing the underlying assumptions, and at the system level. The latter is supposed to shape the "design and formulation of (sets of) intervention policies and programmes" (Amanatidou et al. 2014, p. 426).

[12]   A similar perspective can be also found in the literature dealing with systems theory (e.g. Caffrey and Munro 2017; Borrás and Laatsit 2019) that emphasizes the interplay of different dimensions and the importance of (learning) processes instead of a focus on outcomes only. Borrás and Laatsit (2019, p. 313) identify two main sets of approaches. On the one hand, those departing from an innovation system perspective (Arnold 2004; Hage et al. 2007; Jordan et al. 2008), on the other hand those that rely on synthesis or meta-analysis of existing evaluations (Edler et al. 2008; Magro and Wilson 2013).

for any framework on MOIP to clarify the relationship between different dimensions of impact. Whereas there have been calls for evaluation mixes (Magro and Wilson 2013) along policy rationales, the interaction of impacts adds additional complexity to the analysis that needs to be conceptualized in the framework.

This review made clear that a framework needs to incorporate the system level where the interaction within a mission between science, innovation and societal dynamics takes place (Amanatidou et al. 2014, p. 437; see also Kaufmann et al. 2015, p. 79). However, this does not imply that the interaction with lower levels is neglected (Bührer et al. 2020). **Transformative systemic impacts are accompanied by new requirements for governance and policy-making and the importance of learning processes** and the role of behavioral change (see also Amanatidou et al. 2014; Janssen 2016; Grillitsch et al. 2019). **Whereas these factors might not be linked with a specific pathway, they are cross-cutting prerequisites for the materialization of the anticipated impacts**. **In this regard, holistic and context sensitive frameworks that focuses on mechanisms and conditions can help to understand the complexity of missions.** Against the background of the slow materialization of impacts in case of MOIP, impact assessment should therefore take into consideration how the environment and the governance enables the realization for transformative policies, the more that missions are embedded into a changing mix of priorities and actors (Hekkert et al. 2020).

Finally, a key insight has been the multi-staged process of such complex policies. Especially Hüsing et al. (2017) and Kroll (2019) have highlighted the different dynamics with regard to complex policies that require a distinct focus with different means of analysis (cf. also Joly and Matt 2017; Arnold et al. 2018 arguing in favor of a mixed methods design combining qualitative and quantitative approaches).[13] **For a comprehensive understanding of missions, a thorough understanding of these translation processes is therefore key in order to investigate how missions approach a problem from the input and output side**. Multiple approaches (Janssen 2016; Hüsing et al. 2017; Kalpazidou Schmidt et al. 2017) have pointed to the importance of studying the underlying instruments and measures in order to understand the dynamics at an aggregate level. This is also backed by reports from the ASIRPA evaluation approach (Matt et al. 2017, p. 217), which find different development paths depending on the mode of coordination/instruments used.

As noted in the very beginning of this review: the study of MOIPs has been on the innovation scholar agenda for quite some time and the quest for setting up a well suited concept for assessing their impact is still on. At the same time this literature overview

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13   Cf. also Hekkert et al. (2020) pointing to the difficulties to delineate missions and its actors.

presented a number of promising ideas and approaches that can inspire the development of a comprehensive framework. Thereby this report may help to make the means and steps towards reaching the aspired bold and ambitious goals of MOIP more visible and ultimately feasible in the near future.

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