1. The Evolution of Research and Innovation Policy Paradigms and Associated Evaluation and Indicator Frameworks

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1.1. Introduction

Research and Innovation (R&I) policy follows certain paradigms that provide a rationale for what it should achieve and its benefits and instruments best suited to attain them. While economic growth and competitiveness were the predominant reasons for innovation policy in the past, a new paradigm has solidified. This paradigm increasingly recognises that R&I policy plays a pivotal role in addressing deep and systemic challenges like the ones enshrined in the Sustainable Development Goals (SDGs). More specifically, the importance of R&I policies to simultaneously deal with economic competitiveness

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as well as with public health, social inclusion, and environmental protection is unequivocal. Lundin and Schwaag Serger summarise this development very clearly:

> The theoretical approach to innovation policy is shifting from a predominantly market or system failure rationale to a system or transformative change approach. Consequently, government efforts to promote innovation are moving from a more generic, reactive character – in which implicitly all innovation was seen as potentially contributing to economic growth and competitiveness and therefore 'good' – towards a more directional nature, with policymakers seeking to channel innovation efforts and support towards addressing societal challenges.[3]

Addressing societal challenges will require transformational changes in different sectors of society. The importance of research and innovation in realising such transformation is reflected in the resurging debate on missions. While addressing the foregoing challenges cannot be only relegated to R&I policy, missions underscore the importance of R&I and associated policy instruments in addressing persistent and wicked societal challenges.[4] Put it simple, missions intend to set ambitious objectives in which R&I plays a critical role through the pursuit of a portfolio encompassing programmes, projects, and support measures.

At present, there are examples of indicators that aim to systematically measure the influence of R&I activities on the realisation of overarching societal goals, for example, the SDGs or Agenda 2030. However, currently, there are no indicators at a more granular level (i.e., projects or programmes) that provide guidance and accountability on how they contribute to achieve system transformation. From an environmental perspective, the European Environment Agency (EEA) states that 'there is a gap between established monitoring, data

3. Nannan Lundin and Sylvia Schwaag Serger, *Agenda 2030 and A Transformative Innovation Policy: Conceptualizing and experimenting with transformative changes towards sustainability (Work in process)* (Transformative Innovation Policy Consortium and University of Sussex, 2018), 2.

4. Iris Wanzenböck, et al., 'A framework for mission-oriented innovation policy: Alternative pathways through the problem–solution space,' *Science and Public Policy* 47, no. 4 (August 2020): 474–89, https://doi.org/10.1093/scipol/scaa027

and indicators and the knowledge required to support transitions,'[5] which for Biggeri and Ferrannini entails that there exists 'an open space for innovative proposals for measurement seems to be available.'[6] Such new approaches are critical for two reasons: First, they help to further operationalise the concepts of transformative innovation policy guiding policy makers and legitimacy to decisions and actions. Second, they could contribute to the institutionalisation of this new paradigm by codifying and embedding a certain frame into policy discourses and gradually making it a social fact.[7]

To this end, this research paper provides an overview of the development of R&I policy paradigms over time, contributing to contemporary research and scientific discourse on Transformative Innovation Policy (TIP). Based on the characterisation of Schot and Steinmueller,[8] first, this chapter briefly outlines the main rationale of R&I policy paradigms and then it discusses the evaluation system and indicators associated with it. It is important to note that, to the best of the authors' knowledge, there is currently no fully solidified evaluation system and indicators for transformative innovation policy. These are currently under development and testing.[9] In contributing to this body of research, this chapter draws on the building blocks of TIP developed by Rogge, Pfluger, and Geels as well as Ghosh et al. to develop indicator categories for TIP.[10]

5. European Environment Agency, *The European environment — State and outlook 2015: Synthesis report* (Luxembourg: Publications Office of the European Union, 2015), 8.

6. Mario Biggeri and Andrea Ferrannini, *Framing R&I for transformative change towards sustainable development in the European Union* (Luxembourg: Publications Office of the European Union, 2020), 24.

7. Benoît Godin, *The making of science, technology and innovation policy: conceptual frameworks as narratives, 1945-2005* (Villa Falconieri: Centro Europeo dell'Educazione, 2009).

8. Johan Schot and W. Edward Steinmueller, 'Three frames for innovation policy: R&D, systems of innovation and transformative change,' *Research Policy* 47, no. 9 (August 2018): 1554–67. https://doi.org/10.1016/j.respol.2018.08.011

9. Biggeri and Ferrannini, *R&I for transformative change.*

10. Karoline S. Rogge, Benjamin Pfluger, and Frank W. Geels, 'Transformative policy mixes in socio-technical scenarios: The case of the low-carbon transition of the German electricity system (2010–2050),' *Technological Forecasting and Social Change* 151, no. 4 (March 2018): 119259. https://doi.org/10.1016/j.techfore.2018.04.002; Bipashyee Ghosh, et al., 'Transformative outcomes: assessing and reorienting experimentation with transformative innovation policy,' *Science and Public Policy* 48, no. 5 (October 2021): 739–56. https://doi.org/10.1093/scipol/scab045

1.2. Paradigm 1: Science and Technology

The first paradigm can be subsumed under the term *science and technology* or the first frame of innovation policy.[11] This is because it is influenced by the importance of technological breakthroughs in winning the second world war, as well as an emergence of scientific management practises (i.e., Taylorism). Likewise, it is characterised by the domination of science and technology-driven innovation for the sake of national prowess and economic superiority.[12] In this paradigm, innovation is seen as the means to achieve economic growth, job security, or the realisation of ambitious technology missions (e.g., man on the moon). In short, it consists of a very linear model of innovation, namely: basic research → applied research → development.[13]

This paradigm became institutionalised through patent laws and the establishment of dedicated R&I departments and large-scale laboratories.[14] The need for this innovation policy was legitimised through a requirement to fix market failures and externalities that led to a less-than-ideal innovation output, limited the ability to commercialise scientific results, and hampered economic growth while reducing the ability to achieve missions.[15] In this vein, the negative consequences and side effects of the innovation process were acknowledged but could be remedied by conducting more research and producing more innovation. This understanding rendered innovation as good per se.[16] Finally, it is important to note that the main actors in this paradigm are scientists who are responsible for producing knowledge, state actors, for funding this process,

11. Schot and Steinmueller, 'Frames for innovation policy.'

12. Peter Biegelbauer and Matthias Weber, 'EU research, technological development and innovation policy,' in *Handbook of European Policies: Interpretive Approaches to the EU*, eds. Hubert Heinelt and Sybille Münch (Cheltenham: Edward Elgar Publishing, 2018).

13. Godin, *Science, technology and innovation.*

14. Gijs Diercks, Henrik Larsen, and Fred Steward, 'Transformative innovation policy: Addressing variety in an emerging policy paradigm,' *Research Policy* 48, no. 4 (May 2019): 880–94. https://doi.org/10.1016/j.respol.2018.10.028

15. K. Mathias Weber and Harald Rohracher, 'Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework,' *Research Policy* 41, no. 6 (July 2012): 1037–47. https://doi.org/10.1016/j.respol.2011.10.015

16. Schot and Steinmueller, 'Frames for innovation policy.'

and private actors, embodied as large corporations, for turning knowledge into commercially viable products.[17]

Overview of R&I Monitoring and Evaluation (M&E) System in Paradigm 1

In evaluations, the market failure rationale is closely linked to the concepts of input and output additionality. Input and output additionality analyses study the leverage effects of public funding for R&I in terms of private spending and technological performance. These evaluations focus on the effectiveness of the presumed intervention mechanism, namely, that public incentives increase R&I engagement in the business and that such additional publicly induced R&I activities lead to new products and processes improving Europe's technological performance.[18] Evaluation studies emphasising input and output additionality are by large summative, ex-post evaluations. While these evaluations are capable to analyse the effects of intervention by means of counterfactual econometric and bibliometric analysis, they tell little about the mechanisms that turn an intervention into a success or failure and are of limited use for learning and adaptation.

Overview of Indicators Associated with the M&E System in Paradigm 1

A very linear logic model was underpinning the R&I monitoring frameworks at that time that structured how we understood and measured the value of science, technology, and innovation (once conceptualised in economic terms). The model postulates that innovation starts with basic research, then it adds applied research, after that, it brings development, and it ends with production and diffusion. Hence, only R&D is implied in this paradigm.

A landmark of R&I indicators at that time is the first version of the Frascati Manual conceived in 1963. According to Freeman and Soete, this manual tried to distinguish between research and experimental development and related scientific activities.[19] Moreover, it targeted national statisticians for standardising

17. Ibid.

18. Dirk Czarnitzki and Katrin Hussinger, 'Input and output additionality of R&I subsidies,' *Applied Economics* 50, no. 12 (2018): 1324–41. http://bitly.ws/rhGY

19. Christopher Freeman and Luc Soete, 'Developing science, technology and innovation indicators: What we can learn from the past,' *Research Policy* 38, no. 4, (May 2009): 583–89. https://doi.org/10.1016/j.respol.2009.01.018

surveys and offering a statistical answer and an accounting framework to three policy issues of the time: the allocation of resources to science (i.e., how much the government should invest in science), the balance between choices or priorities (i.e., where to invest), and the efficiency of research (i.e., the results).[20] Thanks to this manual, and for the first time, the collection of standardised statistics was possible, allowing for cross-country comparison.

The main criterion for what was measured (part of R&I) and what was not (not considered part of R&I) consisted of the distinction between novelty and routine. Whilst this was a relatively straightforward criterion for distinction at that time, it led to the exclusion of many activities that would be considered integral in the contemporary understanding of R&I and typically be associated with development. As a result, several aspects of scientific and technical activities at the enterprise level, including consultancy, project feasibility studies, design and engineering, production engineering, quality control, training, and information services were left out and not measured.[21] The rationale for the foregoing criterion is R&I was seen as a specialised activity carried out in specialised private and public institutions. Indeed, a great part of technological progress appeared attributable to research and development work performed in specialised laboratories or pilot plants by full-time qualified staff, while other actors were only seen as important for uptake and diffusion.

The measurement focus was input-oriented and concerned two types of statistics: the financial resources invested in R&I and the human resources related to research activities. A key statistic indicator was that national science budget or gross domestic expenditures on R&I (GERD) conceptualised as the sum of the R&I expenditure in the four main economic sectors: business, university, government, and non-profits.[22] Therefore, it gave rise to the GERD/GDP ratio as a measure of the intensity or efforts of a country or economic sector. The input measure of R&I expenditures gradually became the most widely used measure of innovation (mostly technological) performance of sectors, countries, or firms.

20. Godin, *Science, technology and innovation.*

21. Ibid.

22. Ibid.

In the 1970s and 1980s, there was a substantial increase in the resources devoted to the study of R&I itself. Many governments started to measure R&I activities and the industry itself started to increasingly recognise the role of R&I for comparative strength.[23] This led to a broader perspective on what should be measured and how to interpret it. Innovation itself began to become an increasingly important focal point and the notion of R&I which was seen at that time as industrial research and experimental development input, was increasingly recognised as too narrow. This is because, through the work of business schools and economists, non- R&I-related activities like production and diffusion also became important elements to be measured.

The revision of the Frascati Manual also started to include output indicators that had not been previously included as it was deemed impossible for a standardised format based on available data. It took until 1981 for output indicators to be introduced in R&I statistics. These included patents, technological payments, high technology trade, and productivity. From this point onwards an input-output approach to measuring R&I developed. This approach was predominately concerned with measuring upstream and downstream quantities and establishing a relationship between them.[24] To a large extent, such underlying logic of measurement is attributed to the econometric model of the production function, which links, in basic terms, the quantity of produced goods (outputs) to the quantities of inputs. In short, it stipulated that research leads to economic growth and productivity, placing a premium on investment as a means to achieve growth.

1.3. Paradigm 2: Innovation Systems

In response to the shortcomings of the previous linear approach to innovation, a new paradigm emerged taking on an innovation systems perspective.[25] Rather than just the production of knowledge through science, the actual use

23. Freeman and Soete, 'Science, technology and innovation.'

24. Godin, *Science, technology and innovation.*

25. Diercks, Larsen, and Steward, 'Transformative innovation policy.'

of knowledge moved to the fore, and so did the interactions between different types of actors, in particular, in science and industry.[26] An important focal point for this perspective was how a constellation of different actors and the interactions among them can strengthen the adoption of innovation in the everyday practises of businesses or end-users.[27] The emphasis on learning and collaboration between heterogeneous actors brought new interaction forms to the fore, namely, the capabilities of firms to absorb knowledge and experience from others as well as entrepreneurship as a critical driver for innovative ideas.[28] In addition, the rationale for policy intervention was not only the failure of the but also of an innovation system. This latter limits the ability to make use of knowledge due to weak or malfunctioning links and framework conditions between government, industry, and university.[29] Still, a major premise or assumption that underpinned this paradigm and its associated framework was that science, technology, and innovation are always good – for individuals and good for society at large.[30]

In this paradigm, the role of government is to create beneficial framework conditions so that all sorts of innovation output emerge while the benefits of innovation are still constrained by relatively narrow economic rationales.[31] As such, the innovation system paradigm has also been recognised as insufficient to address the nature and complexity of societal challenges. This is because it is mainly directed at optimising an innovation system for economic purposes largely neglecting other social or environmental goals.[32] The vast majority of the innovation systems literature continues to regard innovation as positive per

26. Doris Schartinger, et al., 'Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants,' *Research Policy* 31, no. 3 (March 2002): 303–28. https://doi.org/10.1016/S0048-7333(01)00111-1

27. Diercks, Larsen, and Steward, 'Transformative innovation policy.'

28. Ibid.

29. Weber and Rohracher, 'Research, technology and innovation.'

30. Godin, *Science, technology and innovation.*

31. Diercks, Larsen, and Steward, 'Transformative innovation policy.'

32. Schot and Steinmueller, 'Frames for innovation policy.'

se even though recent contributions have started to take matters of directionality into account.[33]

Overview of R&I Monitoring and Evaluation System in Paradigm 2

In evaluations, the system failure rationale is closely linked to the concept of behavioural additionality. This concept attempted to widen traditional perspectives in evaluation methods based on input and output additionality and to link them with the policy framework of the national innovation system.[34] Behavioural additionality is considered as the core of an evolutionary/structuralist view which urges policy action to increase the cognitive capacities of agents and/or to resolve exploration, exploitation, selection, system, and knowledge processing failures, rather than simply addressing those of the market.[35] The emergence of the concept of behavioural additionality was strongly needed – as it in fact expressed a 'catching-up' of policy and evaluation theory on already widely applied practises of policy makers to explicitly target behavioural changes in the design of policy instruments.[36]

The focus on behavioural additionality emphasised a resource-based view of the firm[37] and the interactions with public research organisations and collaborators along the value chain. Evaluations of R&I public policies increasingly focussed on the network structures that emerged through public interventions (e.g., the inclusion of new actors and their role in the networks) and the capabilities acquired by the organisations.

33. Marko P. Hekkert, et al,, 'Mission-oriented innovation systems,' *Environmental Innovation and Societal Transitions* 34 (January 2020): 76–79. https://doi.org/10.1016/j.eist.2019.11.011

34. Jan Larosse, 'Conceptual and Empirical Challenges of Evaluating the Effectiveness of Innovation Policies with Behavioural Additionality (The Case of IWT R&D Subsidies),' in *Innovation Science Technology: 'Making the Difference.' The vealuation of 'Behavioral Additionality' of R&D Subsidies*, eds. Ann Van de Bremt and Jan Larosse (Brussels: IWT Observatory, 2004), 57–69.

35. Abdullah Gök and Jakob Edler, 'The use of behavioural additionality evaluation in innovation policy making,' *Research Evaluation* 21, no. 4 (2012): 306–18. https://dx.doi.org/10.2139/ssrn.1980648

36. Ibid.

37. Luke Georghiou and Clarysse Bart, 'Behavioural additionality of R&D grants: introduction and synthesis,' in *Government R&D Funding and Company Behaviour: Measuring Behavioural Additionality*, ed. Organisation for Economic Cooperation and Development (Paris: OECD Publishing, 2006), 9–38. https://doi.org/10.1787/9789264025851-en

Overview of Indicators Associated with the M&E System in Paradigm 2

From a monitoring and evaluation perspective, the National Innovation System concepts took on centre stage in R&I policy-making discourse and practise[38]. However, the concept was ambiguous and 'statisticians simply did not have the appropriate tools to measure [it].'[39] What was used in the beginning was based on the Frascati Manual – R&I expenditure and manpower. In this stage, the flows of these resources between sectors as performers of research activities moved to the fore. Nevertheless, these measures were also regarded as insufficient to measure the diversity and complexity of innovation systems, and new ones such as the innovation survey were developed.[40] Here, new concepts such as the globalisation of research activities, networks of collaborators, clusters, and the role of users emerged. A common denominator, however, was an attempt to measure knowledge flows between entities through surveys. For industry alliances, indicators such as inter-firm research cooperation arose. For industry-university interactions, indicators such as cooperative industry/university R&I, industry/university co-patents, or industry/university co-publications were developed. Similarly, indicators for technology diffusion such as technology used by industry or indicators related to personnel mobility (e.g., the indicator movement of technical personnel among industry, university, and research) were created.[41]

Another landmark of R&I indicators under this paradigm is the Oslo Manual which harmonised innovation-output indicators, leading to a better understanding of both, the science and technology system and the changing nature of the innovation process itself.[42] Its first edition marked a synthesis of the experiences from a broad group of innovation surveys in the late 1980s.[43] It focused on product and process innovation in manufacturing industries and

38. Godin, *Science, technology and innovation.*

39. Ibid., 9.

40. Ibid.

41. Ibid.

42. Freeman and Soete, 'Science, technology and innovation.'

43. Carter Bloch, 'Assessing recent development in innovation measurement: The third edition of the Oslo Manual,' *Science and Public Policy* 34, no. 1 (February 2007): 23–34. https://doi.org/10.3152/030234207X190487

provided a unified framework for collecting this data at the firm level.[44] In its second version, the manual also included innovation in the services sector, which extended to marketing and organisational innovations in its third version.[45] Again, the experiences that were gained through the increase in using national innovation surveys by a range of different countries directly informed the adaptations of the manual and the implementation of the associated community innovation surveys (CIS).

While the system approach has been increasingly recognised and used in R&I policy evaluation, Borrás and Laatsit highlight that only six out of the EU28 countries have developed system-oriented innovation policy evaluation practises (i.e., the Netherlands, Austria, Finland, Germany, Ireland, and Sweden), suggesting system-oriented innovation policy evaluation is not yet the norm in the European Union.[46] In this vein, Borrás and Laatsit argue that 'the limited systemic approach in evaluation means that most policymakers in Europe lack a very important source for policy learning, namely, the source that is based on a careful assessment of their innovation system and policies' performance.'[47]

1.4. Paradigm 3: Transformative Innovation Policy

Most recently, a new field of innovation policy research emerged that is concerned with the role of innovation policy in addressing grand societal challenges. The emergence of this new policy paradigm is based on the recognition that traditional assumptions, goals, instruments, and governance models in research and innovation policy are ill-equipped to address wicked social and environmental challenges.[48] The new innovation policy paradigm is the attempt to better align innovation policy objectives with the social and environmental

44. Ibid.

45. Ibid.

46. Susana Borrás and Mart Laatsit, 'Towards system oriented innovation policy evaluation? Evidence from EU28 member states,' *Research Policy* 48, no. 1, (February 2019): 312–21. https://doi.org/10.1016/j.respol.2018.08.020

47. Ibid., 319.

48. Schot and Steinmueller, 'Frames for innovation policy.'

challenges that prevail.[49] This policy paradigm builds n the two most established innovation policy paradigms and is understood as an additional layer, rather than a complete replacement of older innovation policy paradigms.[50] In fact, a well-functioning innovation ecosystem, in the traditional sense of well-distributed roles and responsibilities across different sectors and levels of government and thematic domains, is the fundament on which more ambitious strategic ambitions can be placed.[51]

In the emerging third frame, the transformation-challenge rationale, the focus of the intervention moves beyond the sphere of R&I policy because solving grand societal challenges cannot be relegated to this policy field alone. Moreover, transformative innovation policy (TIP) adds something to the innovation policy space that was thus far crucially missing: a normative purpose and directionality that goes beyond the general focus on competitive, economic growth, and fixing market and systems failures.[52] Moreover, it departs from the assumption that innovation is always good and that social and environmental negative externalities can be managed ex-post by the state. On the contrary, this paradigm postulates that innovation is not positive per se and that it can lead to more problems than it solves by strengthening existing path dependencies and thereby, perpetuating severe social inequalities and negative environmental consequences.[53] Transformative innovation policy is not only about the transformation of different sectors (e.g., energy and food) but also about fundamental changes in the logic and function of knowledge and innovation systems themselves.[54]

Lastly, Rogge, Pfluger, and Geels posit what TIP should entail and what its evaluation and monitoring should focus on. These authors argue that for TIP

49. Ibid.

50. Diercks, Larsen, and Steward, 'Transformative innovation policy.'

51. Andrea Ricci and Matthias Weber, *Beyond the Horizon. Foresight in support of the preparation of the European Union's future policy in research and Innovation* (UE: European Commission, 2018).

52. Weber and Rohracher, 'Research, technology and innovation.'

53. Johan Schot and Laur Kanger, 'Deep transitions: Emergence, acceleration, stabilization and directionality,' *Research Policy* 47, no. 6 (March 2018): 1045–59. https://doi.org/10.1016/j.respol.2018.03.009

54. Stefan Kuhlmann and Arie Rip, 'Next-generation innovation policy and Grand Challenges,' *Science and Public Policy 45*, no. 4 (February 2018): 448–54. https://doi.org/10.1093/SCIPOL/SCY011

to become effective, it requires greater attention to 1) strategic long-term policymaking with clear direction for desired change that is built on inclusive and anticipatory deliberation; 2) targeted instruments for the creation and destruction side of transition processes (i.e., niche building and regime destabilisation); and 3) the support of new or adjusted existing institutional arrangements, framework conditions, and governance structures conducive to sustainability transitions.[55]

Overview of R&I Monitoring and Evaluation System in Paradigm 3

The purposes for evaluation associated with paradigms 1 and 2 are aimed at understanding and judging the appropriateness, relevance, efficiency, and impact of an intervention in order to provide accountability to the government, taxpayers, and society more broadly.[56] This summative aspect of R&I evaluation is still valid for TIP because of its societal and environmental ramifications. Although this poses fundamental difficulties in the evaluation of such policy (e.g., causalities and assumptions, etc.) excluding this aspect could be problematic.[57] There are other difficulties for TIP evaluation that stem from the long-time horizons between an intervention and the observation of desired changes as well as the link between evaluating a project/programme level and its wider system impact that the policy intervention is trying to achieve.[58]

However, TIP puts an even greater emphasis on the process of learning and the generation of strategic intelligence to adapt strategy and implementation of TIP – it, therefore, places a premium on the formative aspects of evaluation. One recent conceptual advancement in this space is the evaluation approach put forward by Molas-Gallart et al. that is based on socio-technical systems theory and is purely formative. These authors describe this approach as 'part and parcel of a different way of defining and implementing policy, through which

55. Rogge, Pfluger, and Geels, 'Transformative policy mixes.'

56. Erick Arnold, et al., 'How should we evaluate complex programmes for innovation and socio- technical transitions?' Technopolis Group, June 15, 2018, http://bitly.ws/rhGc

57. Ibid.

58. Jordi Molas-Gallart, et al., 'A Formative Approach to the Evaluation of Transformative Innovation Policy,' *Research Evaluation* 30, no. 4 (October 2021): 431–42. https://doi.org/10.1093/reseval/rvab016

the different stakeholders in a policy monitor and reassess policy results as they happen. It is a form of Real Time monitoring embedded in the policy process.'[59]

Molas-Gallart et al. propose a set of principles for the evaluation of TIPS: 1) adopt a formative approach to evaluation; 2) integrate evaluation with policy design and implementation; 3) the evaluation process should be inclusive and participatory; 4) use a mix of methods and techniques; 5) use a nested approach to assess multi-level TIPS; and 6) use a flexible theory of change. These principles adhere to all levels of evaluating TIPS (project, programme, and policy) and have direct implications for the development of indicators for evaluating TIPS. Most notably, the formative approach sustains the reflexive and participatory process that leads to the particularly important indicator development. The authors stress that 'this process is very different from the requirement to find easily quantifiable and difficult to 'game' indicators, which can also allow a comparative measure (usually against a benchmark).'[60] Instead, the process of developing indicators with participants is at the core of the formative logic, and therefore, it becomes part of the TIP intervention itself. Therefore, indicators are a tool to guide the process of reflexive deliberation 'used to inform assessment by the project participants of the degree to which they are making progress into the desired trajectory of change.'[61]

Overview of Indicators Associated with the M&E System in Paradigm 3

The existing sets of indicators associated with Paradigms 1 and 2 described above embrace the concept of transformative innovation policy only to a very limited extent.[62] While there are examples and initiatives of indicators that aim to systematically measure the influence of R&I activities on the realisation of overarching societal goals (such as the SDGs or Agenda 2030) they are currently

59. Molas-Gallart, et al., 'Evaluation of Transformative Innovation.'.

60. Jordi Molas-Gallart, et al. *A Formative Approach to the Evaluation of Transformative Innovation Policy (Working paper)* (Utrecht: Utrecht University, 2020), 20.

61. Ibid., 20.

62. Biggeri and Ferrannini, *R&I for transformative change*.

not well established. There is either a conceptual ambiguity or the data is currently neither available nor systematically collected.[63]

The following section puts forward a set of measurement categories and indicators for this paradigm considering the following building blocks of transformative innovation policy: directionality and participation as well as niche development and regime destabilisation.[64]

Directionality and Participation

This building block of TIP encapsulates the need for an overarching policy strategy with long-term and quantifiable targets and principles for achieving them.[65] Indicators aimed at tracking long-term, challenge-led, and aspirational achievements (e.g., societal missions) are currently developed by different researcher institutes and research projects.[66] Another, a rather well-established body of indicators takes the Sustainable Development Goals (SDG) as a starting point for directionality. For example, the Eurostat SDG indicator comprises 100 indicators structured by the 17 SDG and allows for a statistical representation of SDG trends in the EU countries over the past 5 –15 years.[67] More specifically, a subset of indicator categories related to R&I for achieving the SDGs are:

- Government support for agricultural research and development (SDG#2, zero hunger).
- Gross domestic expenditure on R&I by sector (SDG#9, industry, innovation, and infrastructure).
- Employment in high- and medium-high technology manufacturing and knowledge-intensive services (SDG#9, industry, innovation, and infrastructure).

63. Ibid.

64. Rogge, Pfluger, and Geels, 'Transformative policy mixes.'

65. Ibid.

66. Two examples of these are: for TIPC: http://www.tipconsortium.net/research-projects/proportion-project-prototyping-an-indicator-framework-on-system-innovation/. And for Fraunhofer ISI: https://www.isi.fraunhofer.de/en/competence-center/politik-gesellschaft/projekte/htf2025.html#tabpanel-843723930

67. 'Sustainable Development Goals –Overview,' Eurostat: Your key to European statistics, accessed March 9, 2022. http://bitly.ws/rhH6

- R&I personnel by sector (SDG#9, industry, innovation, and infrastructure).
- Patent applications to the European Patent Office (SDG#9, industry, innovation, and infrastructure).

A starting point for approaching another aspect in this TIP building block (i.e., participation) are existing indicators developed for responsible research and innovation (RRI). In this sense, a few indicators are available. Focusing again on indicators developed in and for the European context, this chapter draws on the report *Metrics and indicators of Responsible Research and Innovation:*[68]

- Models of public involvement in S&T decision-making.
- Policy-oriented engagement with science.
- R&I democratisation index.
- National infrastructure for the involvement of citizens and societal actors in research and innovation.
- Citizen preferences for active participation in S&T decision-making.
- Dedicated resources for public engagement.
- Embedment of public engagement activities in the funding structure of key public research funding agencies.
- Public engagement elements as evaluative criteria in research proposal evaluations.

Niche Development & Regime Destabilisation

This second element of TIP points to the need for transformative innovation policy to target multiple failures (i.e., market, system, transformative) through different types of instruments that support technology-push, demand-pull, and systemic development. This needs to be realised through niche development as well as regime destabilisation.[69] To further specify these fundamental processes

68. Tine Ravn, Mathias W. Nielsen, and Niels Mejlgaard, *Metrics and indicators of Responsible Research and Innovation (Progress Report)* (EU: European Commission, 2015). http://dx.doi.org/10.13140/RG.2.2.12773.40165

69. Bruno Turnheim and Frank W. Geels, 'Regime destabilisation as the flipside of energy transitions: Lessons from the history of the British coal industry (1913-1997),' *Energy Policy* 50 (November 2012): 35–49.

of transformation change, we draw on the transformative outcomes concept because it provides more granular categories which specify important leverage points for niche development and regime destabilisation,[70] allowing for a systematic and functional approach to the monitoring of this TIP building block.

Ghosh et al. posit three core transformative processes in sociotechnical transitions: 1) building or nurturing niches; 2) expanding and mainstreaming niches; and 3) opening up and unlocking regimes. These authors pose a set of twelve transformative outcomes across these processes for transformative change. While transformative outcomes are described in detail in Ghosh et al. the focus here is only on potential indicator categories for them.[71] (See TABLE 1 for an overview).

Process 1. Building and Nurturing Niches

The first process is about the birth and early adoption of new and more sustainable practises in niches. Such practises are promising in potential but rather poorly represented and therefore, they require protection and support. In this vein, Gosh, et al., have identified four transformative outcomes to progress alternative practises, namely: 1) shielding 2) learning 3) networking, and 4) managing expectations.[72] They are defined below:

1) Shielding: It consists of protecting new and more sustainable practises from external influences and helping them grow. Shielding refers to the creation of protective conditions in which innovation can emerge and grow. Potential indicator categories for shielding are:

- R&I budget and subsidies for niche innovation.
- Fiscal support for niches (e.g., taxation).
- Public/Collective purchasing and procurement of niche innovations.
- Voluntary agreements with niche actors.

https://doi.org/10.1016/j.enpol.2012.04.060; Paula Kivimaa and Florian Kern. 'Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions,' *Research Policy* 45, no. 1 (February 2016): 205–17. https://doi.org/10.1016/j.respol.2015.09.008

70. Ghosh, et al., 'Transformative outcomes.'

71. Ghosh, et al., 'Transformative outcomes.'

72. Ibid.

- Supportive regulation for niches.
- Experiments aimed at changing framework conditions (e.g., regulatory sandboxes).

2) Learning: It entails providing regular opportunities for discussing experiences, obstacles, and needs related to a new practise as well as challenging related values and assumptions that people might have. The development of actionable knowledge is a prerequisite for learning. Actionable knowledge is evidence that provides practical guidance on how to solve sustainability problems.[73] Two types of knowledge are important in this regard:[74]

a) Analytical descriptive knowledge about the current system and associated sustainability problems. Possible indicator categories for this type of knowledge are:

- Different types of system maps (e.g., policy landscape, project portfolios, etc.).
- Scientific publications (including conference papers or discussion papers).
- Grey Literature.
- Datasets and databases of environmental or problem-related data.

b) Normative knowledge about sustainability goals and desirable system states. Potential indicator categories for this type of knowledge are:

- Visions.
- Problem framings.
- Scenarios (qualitative, quantitative, or mixed).

73. Christopher Luederitz, et al., 'Learning through evaluation - A tentative evaluative scheme for sustainability transition experiments,' *Journal of Cleaner Production* 169 (December 2017): 61–76. https://doi.org/10.1016/j.jclepro.2016.09.005

74. Arnim Wiek, Kay Braden, and Forrest Nigel, 'Worth the trouble?!: An evaluative scheme for urban sustainability transition labs (USTLs) and an application to the USTL in Phoenix, Arizona,' in *Urban Sustainability Transitions*, eds. Niki Frantzeskaki, et al. (New York: Routledge, 2017), 227–56.

These different forms of knowledge need to be internalised and activated (through deep learning), which ultimately enables actors to act in more sustainable ways in their everyday decision-making and routine practises. This is embodied in the notion of capacities of stakeholders which ultimately allows them to exercise this new knowledge.[75] Luederitz et al. point to three particularly important capacity areas for deep learning:

a) Capacities to develop effective sustainability interventions. Possible indicator categories for this type of capacity are:

- Stakeholder track-record in deploying sustainability initiatives.
- Existence of spin-offs/follow-up projects.

b) Practical skills and knowledge that incorporate sustainability in routine actions. Possible indicator categories for this type of capacity are:

- Evidence that sustainability has been anchored in routines beyond intervention.
- Evidence that sustainability has been anchored in strategies beyond intervention.

c) Interpersonal skills for developing coalitions and alliances. A potential indicator category for this type of capacity is:

- New networks and coalitions that are maintained beyond the project/intervention.

3) Networking: It concerns protecting and progressing new practises by gaining the interest of more people and creating connections between them. Individual actors and actor networks are critical for supporting transformative change processes.[76] At the individual level, championing transformational

75. Wiek, Braden, and Nigel, 'Worth the trouble?'

76. Jacco Farla, et al., 'Sustainability transitions in the making: A closer look at actors, strategies and resources,' *Technological Forecasting and Social Change* 79, no. 6 (July 2012): 991–98. http://dx.doi.org/10.1016/j.techfore.2012.02.001

change is polycentric, top-down as well as bottom-up, and anchored in the local and social context in order to instigate and leverage collective processes (e.g., discourses, social learning, etc.).[77] Possible indicator categories are:

- Number of champions.
- Type of champions (individual, organisational, etc.).
- Position/embeddedness of champions in a network.

Actor networks are critical because they enable them to develop a shared purpose and understanding of a problem and innovative solutions to explore different value propositions, develop relationships, and form coalitions.[78] Potential indicator categories that point to transformative networks are:

- Degree of formalisation of networks (from loosely connected individuals to formal networks).
- Autonomy and resources of networks.
- Heterogeneity of network.
- Inclusiveness of network.

Likewise, intermediaries have been put forward as key actors in developing and leveraging the transformative potential of networks. Possible indicator categories related to intermediary actors are:

- Presence and number of intermediaries.
- Changes in the type of intermediary (individual, organisation, etc.).
- Roles of intermediaries (niche-, regime-, process-, systemic intermediary).
- Position/embeddedness of intermediaries in a network.
- System aggregation level at which intermediaries operate (local, regional, national, international).

77. Marc Wolfram, 'Conceptualizing urban transformative capacity: A framework for research and policy,' *Cities* 51 (January 2016): 121–30. https://doi.org/10.1016/j.cities.2015.11.011

78. Ibid.

4) Navigating expectations: It refers to the fact that navigating and converging expectations of different actors, the legitimacy of new practises is developed, and their potential explored. Collective expectations are a critical resource in innovation processes and can have an important impact on the direction and speed of innovation.[79] In this train of thoughts, narratives and visions are important elements that determine expectations. Potential indicator categories for narratives that can influence expectation dynamics are:

- Presence of a new narrative or signs of an emerging narrative in different outlets (e.g., media, scientific, political, industry publications).
- Wider framing of solution for sustainability issues (i.e., from a narrow problem-solution framing towards a framing that conveys a wider or all-encompassing meaning)
- Changes to advocating narrative/counter-narrative.
- Coalitions around particular framings and narratives.
- Potential indicators for visions are:
- Directionality of existing visions/new visions.
- Increase in reach/buy-in of visions.
- Quality of vision (e.g., co-developed, widely shared, transformational aspirations, etc.)

Process 2: Expanding and Mainstreaming Niches

For transformative change to happen, new and more sustainable practises need to expand in scope and scale. This relates to a process in which alternative practises grow stronger and lead to the reconfiguration or disappearance of more dominant ones. Ultimately, new and more sustainable practises replace previously dominant ones and become the new mainstream. Four transformative outcomes to mainstream new and more sustainable practises have been identified, namely: 1) upscaling, 2) replication, 3) circulation, and 4) institutionalisation.[80]

79. Farla, et al., 'Sustainability transitions.'

80. Ghosh, et al., 'Transformative outcomes.'

Upscaling: It involves conducting deliberate action to get more users involved in new and more sustainable practises. A shared goal among transition projects/initiatives is that they provide generalisable evidence and knowledge on the application of solutions beyond a specific context.[81] This means that practises in transition experiments should be prone to be utilised by different stakeholders beyond the initiative/project in order to address similar challenges either at a different level of the system (i.e., upscaling) or in different contexts (i.e., replicating). Potential indicator categories for upscaling are:

- Number of stakeholders/stakeholder groups that engage with new practise.
- Changes in the number of practises adopted in a specific area/sector and at a certain level (local, national, transnational).
- Changes in the speed of adoption of practise in a specific area/sector and at a certain level (local, national, transnational).

Evaluating this outcome could also mean however to assess the potential of an intervention/experiment to be scalable in the first place, which in terms of Luederitz et al., refers to the scalable properties of a solution.[82] A possible indicator category for these properties could be:

- Cost for an additional application of practise.
- Valorisation of practise by stakeholders.

Replication: It means transferring the new and more sustainable practises to another location. Replication is a particular type of upscaling where the emulating niche is geographically disconnected from the original one. In this vein, it is important for the expansion of niches but it is not a straightforward process. This is because niches are context-specific so replicating niches requires

81. Joannette Jacqueline Bos, Rebecca R. Brown, and Megan A. Farrelly, 'A design framework for creating social learning situations,' *Global Environmental Change* 23, no. 2 (April 2013): 398–412. https://doi.org/10.1016/j.gloenvcha.2012.12.003

82. Luederitz, et al., 'Learning through evaluation.'

adjustments leading to own shielding, learning, and networking strategies. Indicator categories for replication include:

- Practise is applied in different settings/circumstances.
- Independence of practise from cultural (e.g., user preferences) or structural (e.g., governance arrangements) particularities.

Circulation: It encompasses the exchange of knowledge, ideas, and resources between multiple related alternative practises. Circulation of resources (i.e., ideas, rules, products, tools, and people) beyond original niches is a process that facilitates replication. The circulation of such resources triggers learning processes that allow for the embedding of niches in local contexts. Potential indicator categories in this regard comprise:

- Knowledge and experience collection and synthesis.
- External knowledge and experience accessibility.
- Knowledge and experience sharing among stakeholders.

Institutionalisation: It implies turning new and more sustainable practises into more permanent and more widely available ones. Institutionalising is embedding a new practise in established institutional frameworks (cognitive, normative, regulative) across the formal and informal realms.[83] Potential indicator categories for institutionalisation are:

- Guidelines for best practises are developed.
- New standards are developed.
- Existing standards are adapted.
- New laws are developed.
- Existing laws are adapted.
- Practise features in emerging/dominant discourse.

83. Lea Fuenfschilling and Bernhard Truffer, 'The structuration of socio-technical regimes—Conceptual foundations from institutional theory,' *Research Policy* 43, no. 4 (May 2014): 772–91. https://doi.org/10.1016/j.respol.2013.10.010

Process 3: Opening up and unlocking regimes

The ultimate aim is to replace dominant and unsustainable practises. New and more sustainable practises can only become dominant when significant individuals or organisations open up for change, and they have the will to make alternative practises competitive. Such openings provide innovative practises with windows of opportunity to challenge entrenched practise while claiming more space for themselves. The four transformative outcomes to opening up and unlocking dominant practises are: 1) readjusting and destabilising regimes; 2) unlearning and intrinsic learning; 3) strengthening interactions between alternatives and dominators; and 4) changing perceptions of landscape pressures such as the climate crisis.[84]

1) Readjusting and destabilising regimes: It entails disrupting and weakening dominant practises. This can be done by changing one of the dominant dimensions, for example, through the introduction of new policies. Destabilisation refers to the unlocking of path dependencies and a softening of established and entrenched configurations in a socio-technical system. Destabilisation can either happen through top-down (e.g., phase-out policies) or it can be driven more bottom-up (e.g., the salience of societal movements).

From a top-down perspective, some potential indicator categories are:

- Phase-out policies.
- Bans on entrenched practises.
- Removal of subsidies of entrenched practises.
- Targeted financial incentives for alternative practises.

On the other hand, possible indicators from a bottom-up perspective are:

- Public demonstrations, rallies, or marches.
- Boycotts.
- Petitions.

84. Ghosh, et al., 'Transformative outcomes.'

- Media campaigns.
- Public debates.
- Emerging discourses and metaphors.

2) Unlearning and deep learning of regime actors: Dominant actors question their assumptions and change their view on the potential of new and more sustainable practises and the ability of the dominant practise to respond to threats and opportunities, such as climate change and digitalisation. Regime openings create windows of opportunity for the consolidation and upscaling of niches. The opening of a regime refers to a process whereby regimes scape lock-ins and dependency on past trajectories. Thus, opening up is important to enable regime actors to see alternative options and new opportunities and pressures clearly. A regime starts to open up when actors begin to question their own assumptions, cognitive beliefs, and values, or the very institutional core of the regime. In this regard, indicator categories encompass:

- Evidence that new problem framings are being adopted by regime actors, e.g., in regime publications and advertisement campaigns.
- Evidence of changes in the direction of routine (R&I) search processes (i.e., moving into previously unexplored areas of knowledge).
- Existence of re-skilling, retrofitting, and repurposing programmes.

3) Strengthening regime-niche interactions: It refers to the frequency and quality of interactions between empowered actors from the niche and the regime on a non-competitive basis. Transitions research has shown that processes of opening up and unlocking regimes are often characterised by interactions of regime actors with niche actors. The increased number of interactions between niches and regimes is a sign of regime destabilisation and further evidence of the opening up of regimes to niches. Indicator categories for such interactions are:

- Establishment of partnerships and collaborations between regime and niches.

- Corporate venture capital initiatives for niche innovations.
- Merges and acquisitions between the regime and niche actors (e.g., firms).

4) Changing perceptions of landscape pressures: In this case, dominant actors reach the point of view that immediate action is warranted, and new emerging and more sustainable narratives need to be promoted. In the multi-level perspective, the landscape comprises macro processes, i.e., long-term and slow-moving trends such as climate change or rapid external shocks like the COVID-19 pandemic. Within these processes, regime and niche actors have little agency to change them (at least in the short term) because they directly influence the contexts of niches and regimes. On the other hand, different landscape trends may or may not align to destabilise a regime. Yet, the regime perception that these trends are increasingly overwhelming, either threatening or creating opportunities for a regime to transform, is critical in a socio-technical transition. Indicator categories for such changing perceptions of landscape pressures include:

- New regime discourses and narratives (framing) around a landscape trend (e.g., climate change).
- Announcement of new strategies, products, or services that seek to address pressure or benefit from an opportunity at the landscape level.

Institutional and Governance Adjustments

Transformative innovation policy calls for new institutional arrangements and governance structures that are oriented towards the achievement of societal goals and include governments, market actors, and civil society.[85] Here, the subset of composite RRI indicators developed by Ravn et al. provides a valuable starting point.[86] Examples of indicator categories are:

85. Rogge, Pfluger, and Geels, 'Transformative policy mixes.'

86. Ravn, Nielsen, and Mejlgaard, *Metrics and indicators*.

- Governance for responsible research and innovation.
- Existence of formal governance structures for RRI within research funding and performing organisations.
- Share of research funding and performing organisations promoting RRI.

Other indicator categories in this space can be drawn from more industry-specific indexes. These would need to be adapted however if a TIP has a specific sector focus. One example that can inform TIP indicators in this space is the water-sensitive city index. [87] While this index was developed for tracking transformative processes in the urban water management sector, certain themes such as cross-sectoral collaboration, equity in decision making, or the importance of natural resources in regulatory frameworks are elements that provide valuable guidance on developing TIP indicators more generally. In this sense, the water sensitive city index[88] identifies the following indicator categories in the area of good governance:

- Knowledge, skills, and organisational capacity.
- Water is a key element in city planning and design.
- Cross-sector institutional arrangements and processes.
- Public engagement, participation, and transparency.
- Leadership, long-term vision, and commitment.
- Water resourcing and funding to deliver broad societal value.
- Equitable representation of perspectives.

87. Beck, Lindsey, et al., 'Beyond Benchmarking: A Water Sensitive Cities Index,' paper presented at the *OzWater Conference*, Melbourne, Australia, May 2016. http://bitly.ws/rhGd; Briony Rogers, et al., 'Water Sensitive Cities Index: A diagnostic tool to assess water sensitivity and guide management actions,' *Water Research* 186 (November 2020): 116411. https://doi.org/10.1016/j.watres.2020.116411

88. Ibid.

TABLE 1. Indicator Categories for Transformative Outcomes[89]

Process	Transformative Outcome	Indicator Categories	Example of Indicators for Some of the Categories [unit]
Building and nurturing niches	Shielding: protecting new and more sustainable practises from external influences and helping them grow.	• R&I budget and subsidies for niche innovation. • Fiscal support for niches (e.g., taxation). • Public/Collective purchasing and procurement of niche innovations. • Voluntary agreements with niche actors. • Supportive regulation for niches. • Experiments aimed at changing framework conditions (e.g., regulatory sandboxes).	• Business and government expenditures in r&i (euros). • Subsidies and tax credits (euros). • Procurement contracts (euros). • The stringency of the regulation (qual.). • The number of experiments (count.).
	Learning: providing regular opportunities for discussing experiences, obstacles, and needs related to a new practise as well as challenging related values and assumptions that people might have.	• Analytical descriptive knowledge about the current system and associated sustainability problems: • Different types of system maps (e.g., policy landscape, project portfolios, etc.). • Scientific publications (including conference papers or discussion papers). • Grey literature • Datasets and databases of environmental or problem-related data.	• Network maps (qual./visual). • The number of publications per year (count.). • Types of framing: technological, • behavioural, economic, etc. (qual.). • The number of projects (count). • The number of routines and strategies (count.). • The number of coalitions (count.).

89. This was developed with Penna, C. C. R., Schot, J., Romero, O., Brodnik, C., Dinges, M., Weber, M., & Matti, C. (2020). EIT Climate KIC Report: Methodological aspects of the prototype of the indicator framework for systemic change and transformation.

Process	Transformative Outcome	Indicator Categories	Example of Indicators for Some of the Categories [unit]
		• Normative knowledge about sustainability goals and desirable system states: • Visions. • Problem framings. • Scenarios (qualitative, quantitative, or mixed). • Capacities to develop effective sustainability interventions: • Stakeholder track record in deploying sustainability initiatives. • Existence of spin-offs/follow-up projects. • Practical skills and knowledge that incorporate sustainability in routine actions: • Evidence that sustainability has been anchored in routines beyond intervention. • Evidence that sustainability has been anchored in strategies beyond intervention • Interpersonal skills for developing coalitions and alliances. • New networks and coalitions that are maintained beyond the project/intervention.	
	Networking: protecting and progressing new practises by gaining the interest of more people and creating connections between them.	• Champions / Individuals: • The number of champions. • Type of champions (individual, organisational, etc.). • Position/embeddedness of champions in a network.	• The number of champions (count.). • Network metrics (indexes/quant.). • Number [count.] and type of intermediaries (qual.).

Process	Transformative Outcome	Indicator Categories	Example of Indicators for Some of the Categories [unit]
		• Actors' networks: • Degree of formalisation of networks (from loosely connected individuals to formal networks). • Autonomy and resources of networks. • Heterogeneity of network. • Inclusiveness of network. • Intermediaries: • Presence and number of intermediaries. • Changes in the type of intermediary (individual, organisation, etc.). • Roles of intermediaries (niche-, regime-, process-, systemic intermediary). • Position/embeddedness of intermediaries in a network. • System aggregation level at which intermediaries operate (local, regional, national, international).	
	Navigating expectations: navigating and converging expectations of different actors the legitimacy of new practises is developed, and their potential explored.	• Narratives: • Presence of a new narrative or signs of an emerging narrative in different outlets (e.g., media, scientific, political, industry publications). • Framing of solutions to sustainability issues widens (from a narrow problem-solution to a wider meaning). • Changes to advocating narrative/counter-narrative.	• The number of newspaper articles (count.). • The number of parliamentary discussions (count.). • Opinion polls (qual.-quant.). • Semantic metrics for narratives (qual.-quant.) • The number of different coalitions (qual.).

Process	Transformative Outcome	Indicator Categories	Example of Indicators for Some of the Categories [unit]
		• Coalitions around particular framings and narratives. • Visions: • Directionality of existing visions/new visions. • Increase in reach/buy-in of visions. • 'Quality' of vision (e.g., co-developed, widely shared, transformational aspirations, etc.).	
Expanding and mainstreaming niches	Upscaling: conducting deliberate action to get more users involved in new and more sustainable practises.	• Scaling: • The number of stakeholders/stakeholder groups that engage with new practise. • Changes in the number of practises adopted in a specific area/sector and at a certain level (local, national, transnational). • Changes in the speed of adoption of practise in a specific area/sector and at a certain level (local, national, transnational). • Scalable potential: • Cost for an additional application of practise. • Valorisation of practise by stakeholders.	• Demand size for a niche (euros). • Cost estimate for niche practise adoption (euros).
	Replicating: transferring the new and more sustainable practises to another location.	• Replicating: • Practise is applied in different settings/ circumstances. • Replication potential: • Independence of practise from cultural (e.g., user preferences) or structural (e.g., governance arrangements) particularities.	• Number of different geographical markets for niches (count.).

Process	Transformative Outcome	Indicator Categories	Example of Indicators for Some of the Categories [unit]
	Circulating: exchanging knowledge, ideas, and resources between multiple related alternatives practises.	• Knowledge and experience collection and synthesis. • External knowledge and experience accessibility. • Knowledge and experience sharing among stakeholders.	• The number of accesses to a website (count.). • The number of attendees in a workshop (count.). • The number of recipients of newsletters (count.).
	Institutionalising: turning new and more sustainable practises into more permanent and more widely available ones.	• Guidelines for best practises are developed. • New standards are developed. • Existing standards are adapted. • New laws are developed. • Existing laws are adapted. • Practise features in emerging/dominant discourse.	• The number of guidelines, standards, laws, etc. (count.).
Opening-up and unlocking Regimes	De-aligning and destabilising regimes: disrupting and weakening dominant practises. This can be done by changing one of the dominant dimensions for example through the introduction of new policies.	• Top-down: • Phase-out policies. • Bans on entrenched practises. • Removal of subsidies of entrenched practises. • Targeted financial incentives for alternative practises. • Bottom-up: • Public demonstrations, rallies, or marches. • Boycotts. • Petitions. • Media campaigns. • Public debates. • Emerging discourses and metaphors.	• Number and stringency of policies (count. and qualitative). • The number of grassroot events (count.). • Opinion polls (qual.-quant.).

Process	Transformative Outcome	Indicator Categories	Example of Indicators for Some of the Categories [unit]
	Unlearning and deep learning in regimes: dominant actors question their assumptions and change their view on the potential of new and more	• Evidence that new problem framings are being adopted by regime actors, e.g., in regime publications and advertisement campaigns. • Evidence of changes in the direction of routine (R&I) search processes (i.e., moving into previously unexplored areas of knowledge);.	• Types of media and marketing campaigns (qual.). • The number of patents (beyond regimes core area) (count.). • The number of programmes (count.).
	sustainable practises and the ability of the dominant practise to respond to threats and opportunities, such as climate change and digitalisation.	• Existence of re-skilling, retrofitting, and repurposing programmes.	
	Strengthening regime-niche interactions: frequency and quality of interactions between empowered actors from the niche and the regime on a non-competitive basis.	• Establishment of partnerships and collaborations between regimes and niches. • Corporate venture capital initiatives for niche innovations. • Merges and acquisitions (M&A) between the regime and niche actors (e.g., firms).	• The number of partnerships (count.) size of venture capital funds (euros). • Number and size of M&A (count. / euros).
	Changing perceptions of landscape pressures: dominant actors to reach the point of view that immediate action is warranted, and new emerging more sustainable narratives need to be promoted.	• New regime discourses and narratives (framing) around a landscape trend (e.g., climate change). • Announcement of new strategies, products, or services that seek to address a pressure or benefit from an opportunity at the landscape level.	• Semantic metrics (qual.-quant.). • The number of announcements (count.).

Source: Prepared by authors in collaboration with Penna et al.[90].

90. Ibid.

1.5. Discussion and Concluding Remarks

As described by Schot and Steinmueller, innovation policy has thus far been dominated by two frames: a linear way of supporting R&I on one hand and a more multi-faceted way of developing innovation systems on the other.[91] This chapter highlights that both frames are characterised by well-established evaluation approaches and indicator frameworks. Nonetheless, a new and transformative innovation policy frame is emerging and has been increasingly recognised in innovation research and policymaking. This third framework of innovation policy thus does not have a fully solidified monitoring and evaluation approach yet, which entails a lack of indicators for assessing innovation policy concerning system transformation.

To this end, this chapter puts forward a theory-based approach to developing indicator categories that draw heavily on TIP building blocks as well as transformative outcomes.[92] Importantly, however, the indicator categories (see TABLE 1) posited here are informed by a range of different sources and they are by no means exhaustive or definitive. As such, they shall serve as a theory-based and conceptual starting point for further developing TIP indicators. As TABLE 1 indicates, development can be achieved in some instances by using well-established indicators (e.g., R&I expenditure, journal publications, or patents) while others will require new techniques (e.g., data mining, semantic analysis, network analysis) or new data sets. In any case, these indicators cannot always be easily interpreted and will need sense-making. To this end, a transformative theory of change can be relevant in structuring and guiding such a process.

Clearly, an important next step would be the empirical testing, application, and validation of these indicators with TIP initiatives in order to fill those categories with life.[93] For this process, it will be paramount to adapt and tailor the indicator categories to the scale and nature of the TIP (e.g., project, programme,

91. Schot and Steinmueller, 'Frames for innovation policy.'

92. Rogge, Pfluger, and Geels, 'Transformative policy mixes;' Ghosh, et al., 'Transformative outcomes.'

93. Note that such work is currently undertaken in the MOTION project which is applying and testing some of these indicator categories with TIP initiatives: http://www.tipconsortium.net/experiment/the-motion-project/

or instrument) to facilitate learning and reflection with them. This is critical, from an evaluation point of view where proponents such Molas-Gallart et al. and Dinges et al. stress the importance of a formative approach as the basis for improving the transformative potential of a policy.[94]

This chapter argues that without this bottom-up adaptation, indicator categories are prone to the risk of becoming too abstract and meaningless for fostering learning about an intervention. In this train of thought, it is crucial to co-create this adaptation process with TIP initiatives by working closely with TIP initiatives when indicator categories are developed, tailored, and applied. Hence, the co-creation of indicators becomes itself important learning and thus highly formative evaluation intervention. It thereby creates indicators that are meaningful and relevant to TIP actors, which is key for their usefulness and application. Besides, because the issue of causality is particularly pertinent in matters of transformation and complex system dynamics, this chapter claims that tailoring indicators through a co-creation approach can strengthen the robustness of an indicator and the phenomenon it seeks to capture and track.

An additional argument for such an approach ought to be made considering that it is grounded in a paradox of measuring transformation: some signs of transformation must change their meaning as the transformation unfolds. In other words, what can be considered a signal for transformation at one point in time can be reckoned as a signal for new stability at a later point in time. For this reason, this chapter advocates for a bottom-up and tailor-made approach to indicator development that is better able to adapt itself to the phases of a change process and capture changes in meaning.

It is worth acknowledging that such a tailor-made approach requires time and effort and poses challenges. This is particularly the case when multiple TIPs need to be evaluated from a portfolio perspective (e.g., multiple projects as part of a programme or call). Furthermore, it is important to note that while formativeness

94. Molas-Gallart, et al., 'Evaluation of Transformative Innovation;' Michael Dinges, Susanne Meyer, and Christoph Brodnik, 'Key Elements of Evaluation Frameworks for Transformative R&I Programmes in Europe,' *Journal for Research and Technology Policy Evaluation* 51 (November 2020): 26–40. https://doi.org/10.22163/fteval.2020.489

is paramount, accountability cannot be disregarded when it comes to policy – particularly when an intervention aims to be transformational. Bottom-up tailoring, however, would make accountability objectives more difficult to achieve and opens avenues for TIP actors to take part in the process by acting strategically. These issues raise the question: to what extent a generalisation of TIP indicators can and should be achieved and how practicable the tailoring of indicators for formative evaluation in TIP really is? Further empirical and theoretical work will be required to answer this question and to work towards an operational, generally applicable, and yet context-sensitive indicator framework for TIP monitoring and evaluation. As this is an exploratory research paper, it is expected that the indicator framework put forward here is useful for categorising measuring targets and signals for TIP. In doing so, it aims to effectively support the sense-making processes of this important innovation policy paradigm.

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