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Exploring the pathways: Regulatory experiments for Sustainable Development – an interdisciplinary approach

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Abstract:

The Sustainable Development Goals (SDGs) adopted by the United Nations provide normative orientation for many national and regional governments as well as actors from industry and other parts of the civil society. There is growing consensus that the corresponding transformation processes needed – e.g. in the field of production and consumption patterns (SDG 12) – have to be fostered by a corresponding institutional framework. Properly designed regulatory experiments that generate a learning system for all actors involved may be an important building block. Based on an interdisciplinary approach, we develop an overview of the various terminologies for regulatory experimentation currently discussed in the social sciences, derive common criteria for regulatory experimentation in reflexive governance structures and conclude in presenting a conceptual framework for analysing empirical studies of regulatory experiments.

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1 Introduction

This paper aims to facilitate the inclusion of regulatory experimenting for sustainable development in future governance structures. Regulatory experiments can potentially optimise regulatory governance since policy-makers and regulators face major uncertainty concerning the future impact of their decisions on such transformation processes.

The core meaning of the term sustainable development is still captured by the 1987 Brundtland Commission definition: "A development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). The United Nations also adopted a very broad approach to sustainable development when defining the seventeen Sustainable Development Goals (SDGs), which take into account the debate on the so-called 'planetary boundaries' (Rockström et al., 2009)[1]. Under the title "Transforming our World", the Agenda 2030[2] lists more than 170 action points, most of which are ultimately intertwined. National translations of the global approach such as the German government's sustainability strategy also follow a broad approach regarding what constitutes sustainable development (German Federal Government, 2016, updated 2017).

From the SDGs, it is clear that the transformation of consumption and production processes requires more than classical technical innovations. In order to bring about a fundamental change towards avoiding emissions and a resource-efficient production and consumption, social and organisational innovations are essential, since actors with diverging interests have to cooperate along global supply chains. An example of this required cooperation is the European chemicals regulation REACH. It implemented the "no data, no market" principle and thus forced producers to unveil (at least partly) their formerly exclusive knowledge on substance properties, which holds value to downstream users, authorities, academic researchers and the public, including competitors (Führ and Bizer, 2007). This regulation simultaneously targets "a high level of protection of human health and the environment" as well as "competitiveness and innovation" (Art. 1(1) REACH).

An encompassing view on sustainable development means that every political initiative and legislative proposal must balance a set of conflicting issues in terms of goal attainment. Although the SDGs guide the problem of regulatory choice, many of them can be in conflict and require legislators to accept trade-offs. The SDGs recognise this challenge and highlight the importance of governance mechanisms and the cooperation of actors as the solution. Under the title "Strengthen the means of implementation", SDG 17 emphasises the necessity to "Enhance policy coherence for Sustainable Development".

Regulatory experiments in reflexive governance structures have the potential to guide regulatory choice when faced with complex structures and uncertain outcomes. Broadly stated, reflexive governance systems use information about the effects of existing regulations to improve them. Regulatory experiments are one way to generate this information. Since sustainable development is not a final state but rather a continuous process, experimentation with alternative regulation appears to be even more helpful in this case. The global aim to "transform our world" is undoubtedly a long and complicated process that can benefit from reiterated search and learning phases[3] by industry actors subject to regulations, civil society as well as among administrative executives and politicians involved in drafting regulatory initiatives.

Reflexive governance in general and regulatory experimentation in particular are a challenging field of study. The literature uses various terminologies for experimentation in the social sciences, yet the extent to which they overlap or depict different artefacts has not yet been considered. While case studies of single experiments already exist, a general approach of categorising experiments suitable as an empirical basis for general recommendations for a widespread use of the tool is lacking. This in turn hampers its further use by regulators and researchers working on specific regulatory problems.

This paper contributes to the existing literature by providing an interdisciplinary discussion of regulatory experimentation as a reflexive governance tool. We explain the different concepts that exist for experimenting with regulation and review their differences and similarities. We also propose a method for categorising regulatory experiments as a tool for future empirical studies on regulatory experiments to facilitate systematic data collection. We adopt an interdisciplinary approach to address these questions and explicitly anchor our analysis of regulatory experiments in reflexive governance structures with the aim of fostering sustainable development.

The remainder of this paper is structured as follows. Part 2 argues that sustainable development requires reflexive governance and proposes a working definition for the latter. Part 3 examines the concepts used for experimentation in the social science literature, before part 4 addresses practical challenges to experimentation. Part 5 details

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[1] Climate change, biodiversity loss, biogeochemical, ocean acidification, land use, freshwater, ozone depletion, atmospheric aerosols and chemical pollution.

[2] Information about the 2030 Agenda for Sustainable Development and the Sustainable Development Goals can be found online (07.05.2019): http://ec.europa.eu/environment/sustainable-development/SDGs/index_en.htm .

[3] In addition, SDG 17.16 reads as follows "Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries".

our criteria developed to categorise regulatory experiments, which provide the basis for systematic data collection and regulatory learning processes. Finally, part 6 concludes.

2 Reflexive governance for sustainable development

Sustainable development, reflexive governance and the role of knowledge

Sustainable development relies on constant sustainable innovations, whose occurrence in the market in turn depends on whether innovators see an opportunity to make a profit. This again depends on the surrounding regulatory framework, which can drive (as well as hinder) innovation. Since all regulation aims to influence actors' behaviour in a certain way, it should hold strong interest to the regulator to ascertain how actors respond to different regulatory options.

Reflexive governance understands the interaction between the regulator and its addressees as a two-way communication. According to Voss and Kemp (2006), it implies constantly calling into question the foundations of governance itself, i.e. concepts, practices and institutions. Reflexive governance structures assess the intended as well as unintended effects of regulation and integrate this knowledge into future regulation. These structures also adapt to changing regulatory objectives and contexts. Optimally, regulation itself can adapt more specifically to the behaviour of its addressees, which has been studied in the literature on responsive regulation (Ayres and Braithwaite, 1992; Bizer, Führ and Hüttig, 2002).

Our starting premise is that a responsive and reflexive approach to governance is necessary for sustainable developments in economic and social systems. Sustainable development defined in a broad sense is multi-faceted, which the definition of altogether seventeen SDGs illustrates. A transformation towards sustainability must take into account the linkages between the various dimensions. For instance, regulation aiming to promote SDG 2 of "zero hunger" may also have consequences for SDG 15 concerning "biodiversity, forests, and desertification". Clear trade-offs are also present. For instance, as long as economic growth and emissions in absolute terms are not decoupled, SDG 13 of fighting climate change will conflict with SDG 8 of achieving sustainable growth. The complexity further increases since each dimension comprises many diverse but linked challenges.

The regulators' toolkit to lead societies towards sustainable developments is large and spans setting legal standards, incentivising systems such as taxes, subsidies and tradeable permits, as well as "softer" interventions such as nudges, voluntary schemes and information campaigns. Often, he chooses one regulatory option without knowing its impacts on the desired outcome, as ex-ante policy evaluation is challenging (Greenstone 2009). Furthermore, the existence of path dependencies in regulation (see e.g. Briglauer et al., 2017; and Modell et al., 2007) can lead to an ever-increasing number of potentially ineffective regulations, since choosing an inappropriate regulatory tool today will increase the chance of inefficient regulatory choices in the future. In contrast, reflexive governance systems produce the knowledge necessary for policies towards societal sustainability.

Knowledge is multi-dimensional and the literature proposes several knowledge typologies. The field of sustainability research distinguishes between system, target and transformation knowledge (ProClim, 1997; Becker and Jahn, 2000; Jahn and Keil, 2016). System knowledge describes knowledge about the actual state of structures and processes. Target knowledge (or orientation knowledge) refers to knowledge about the evaluation of the actual state and decision-making processes. Finally, transformation knowledge contains knowledge about how to realise transformations of the current state of societal structures and processes.

According to ProClim (1997), a combination of all three forms of knowledge is necessary to achieve sustainable development. However, in line with the conclusions in Jahn and Keil (2016), we argue that transformation knowledge is likely to be particularly important for sustainable developments since this requires major changes in terms of how we organise economic and social systems.

Regulatory learning

We denote the provision of knowledge required for reflexive governance as regulatory learning. It is possible to distinguish between various types of regulatory learning. Radaelli (2009, pp. 1046-1047) defines learning in public policy analysis as "a process of updating beliefs about key components of policy (such as problem definition, results achieved at home or abroad, goals, but also actors' strategies and paradigms)". Hence, through what we will refer to as 'vertical learning', the regulator learns from the effects of regulations on various societal stakeholders and continuously adjusts them accordingly.

Munaretto and Huitema (2012) call 'relational learning' what "relates to issues such as trust building, changes in the ability to cooperate, and changes in the ability to understand another party's goals and preferences". We will refer to this type of learning as 'horizontal learning'. Such interactions in the regulatory process enable all stakeholders to reveal their preferences to the policy-maker, problems stemming from asymmetrical information that is common in public policy are relieved, and finally it strengthens the accountability of government (United Nations, 2008).

Systematic improvements in regulatory practices demand an institutional setup explicitly geared towards regulatory learning. Identifying the institutional practices that successfully generate regulatory learning is therefore key. Greenstone (2009) provides a four-step example of an institutional framework for vertical learning. First, the implementation of regulations makes it possible to evaluate their causal effects. Second, one must secure financing for independent evaluations of existing regulations (i.e. by establishing independent regulatory review boards). Third, he recommends that all new regulations contain a set evaluation date as well as automatic sunset and expansion provision to generalise regulations that work and drop those that do not. Finally, he recommends developing a code of ethics to improve potentially negative public associations with the proposed framework.

For horizontal learning to take place, the participation of a variety of stakeholders is the first requirement. Beyond this, the quality of their interactions – such as how stakeholders can express their preferences, the reconciliation of conflicting preferences, and the involvement of stakeholders in the process of implementing, monitoring and evaluating regulations – is key to successful regulatory learning (United Nations, 2008).

The literature provides us with some clues concerning the conditions under which individuals interact in constructive ways. Results from spatial clustering analysis show that geographic proximity is important for interactive learning. This argument goes beyond practicability, whereby areas for common norms and values facilitate interactions (Grillitsch et al., 2017) and regions contain specific firms, infrastructure, knowledge and institutions that tie firms, customers, research institutions and local authorities to each other (Malmberg, 1996). One should nevertheless not exclude the possibility of interregional knowledge exchange (Vang and Chaminade, 2007; Fitjar and Huber, 2015; and Grillitsch and Nilsson, 2015). In multi-level governance systems, intra- and interregional exchange is crucial for regulatory learning. Finally, the type of knowledge used by stakeholders matters for whom interacts with whom (Grillitsch et al., 2017).

Horizontal learning processes not only concern how regulation is shaped, but they also encourage firm innovations that emerge through collaborations involving several stakeholders instead of innovations that occur isolated in one firm. The role of the regulator in these constellations relates to building up appropriate governance structures and possibly by providing public funds for innovation support. Hence, actors in the regulatory process must learn – through trial and error – both how to generate innovative regulatory processes and how to foster innovative developments in the market.

Tools for reflexive governance

Regulatory learning may come about by several means. The most basic approach is systematically evaluating the outcomes of the legal framework in place to identify shortcomings. Furthermore, findings from laboratory experiments can offer additional insights into the effects of specific regulations or institutional arrangements. Furthermore, through scenario processes one can gain a better understanding of medium- and long-term developments initiated by regulation. Moreover, simulation games involving experts and practitioners in the field as well as desk officers enable testing the interplay of actors under an amended legal framework. Finally, regulatory experiments generate regulatory learning.

Experimentation- or flexibility clauses in laws are one tool for regulatory experimentation (Maaß, 2003). Experimentation clauses authorise the executive to deviate from the existing law by a predefined degree. They allocate legal flexibilities or financial support for socio-technical or administrative innovations (Schwarting, 2003), thus enabling the administration to carry out innovative projects, which may subsequently become a permanent part of the regulatory framework (Maaß, 2003). In Germany, municipal law, traffic law, laws on childcare and school legislation all contain several examples of experimentation clauses. For instance, BMWi (2019) provides a detailed overview of different types of experimentation clauses and how they are implemented in Germany.

While experimentation clauses are well suited to test specific socio-technological innovations, it is helpful to take a broader view on experimentation to guide sustainable development processes. Social transformation processes require testing alternative (regulatory) options against one another. Furthermore, these are not linear processes and the design of governance structures should therefore facilitate regulatory changes when new technological developments occur. Experimentation for sustainable development therefore extends beyond the opportunity to test regulatory procedures to facilitate much broader systemic innovations including technical and social dimensions and new business models. The next chapters examine regulatory experimentation as a tool for reflexive governance in detail.

3   Regulatory experimentation

Our approach to experimenting in the social sciences

Experiments test clearly-defined hypotheses by analysing the decision-making of actors under specific institutional settings. The aim is to identify specific patterns for decision-making either over time for the same individual (within-subject) or across groups of different individuals (between-subject). For this purpose, a control group that

is unaffected by the considered treatment is necessary to ensure causal relationships between a given institutional setting and its behavioural effects.

While the natural sciences primarily rely on experimentation to identify cause and effect, the use of experiments in the social sciences is (relatively) new. Li and Van Ryzin (2017) review the number of experimental studies in public management journals and find that the yearly number has increased from 2-4 in the early-1990s to eighteen in 2015. It is also worth noting that experimental studies are mostly constrained to a few topics (climate governance, social policy and education) (Huitema et al., 2018).[4]

The ideal approach for experimenting in the social sciences is to introduce alternative regulations in different parts of the same entity for a limited amount of time before evaluating their consequences and deciding on the best approach. However, this approach is unrealistic for most regulatory processes due to both political and legal restrictions. In the following, we assemble a number of elements that together may constitute a regulatory experiment in the social sciences.

The expected knowledge gain from experiments in the social sciences usually relates to the interactions of the relevant actors in the field, including different economic entities, public bodies and citizens. For this purpose, the design of an experiment should not only specify substantive requirements such as specific legal duties and obligations, but it should also contain procedural elements and mechanisms for ensuring transparency to the public.

In addition, an experiment should take place in an identifiable area with a "control group" in the sense that all other actors outside the experiments base the decision-making on the unaltered regulatory framework. Delimitations in terms of time, range, problem situation and/or subject matter can all define the affected area. Ensuring a control group is more difficult and it is unlikely to be a perfect counterfactual since individuals within the experimental area often deviate from those outside it to some extent. While one can surely accept many alternative control groups as second best, the evaluation of a regulatory experiment should nevertheless reflect and address this issue.

Since the ultimate aim of a regulatory experiment is to generate new knowledge and regulatory learning, a regulatory experiment must include specific monitoring mechanisms. A regulatory experiment furthermore involves cooperation between various stakeholders, among which the regulator is naturally an important player. As its output (i.e. improved regulation) is a public good, the regulator may want to consider compensating participating actors, especially if they are confronted with additional costs as a result of the experiment.

To sum up our approach to what we refer to as regulatory experimentation in the social sciences, we consider the following aspects important: Testing explicit hypotheses, the existence of interactions between different actors, the presence of a control group that need not be a perfect counterfactual as well as monitoring processes to ensure learning. Succesful experimentation becomes even more important in the context of sustainable development and such experiments must be inclusive and should lead to both vertical and horizontal regulatory learning.

Overview of terminology

In the social sciences, one encounters various terms and definitions for the act of experimenting with regulation. Policy experimentation or simply experimentation is one commonly-used concept, although what it actually means remains open to debate. In their discussion of policy experimentation in the social sciences, Huitema et al. (2018) highlight the need for some common understanding of the concept as it is not helpful to categorise every policy as an 'experiment', yet to date conceptual clarity is lacking. Moreover, Ansell and Bartenberger (2016, p. 64) highlight that "even a quick scan of the […] literatures reveals that they do not necessarily mean the same thing when they use the term 'experiment'".

According to Campbell (1997), randomisation is the defining feature of experimentation. For McDermott (2002), experiments are cases in which the investigator has control over the recruitment, assignment to random conditions, treatment, and measurement of subjects. Castán Broto and Bulkeley (2013) consider experiments as novel, purposive initiatives emerging outside a formal policy process. Both Farrelly and Brown (2011) and Bos and Brown (2012) propose a similar understanding of experiments as alternative policy processes that enact new ideas with the aim of identifying ways to upscale them. The authors highlight that policy experimentation is a deductive procedure whereby an underlying theory is proven correct or incorrect. As such, the existence of a hypothesis to be tested is a necessary condition for a policy experiment. McFadgen and Huitema (2017, p. 1768) define policy experimentation as "a temporary, controlled field-trial of a policy-relevant innovation that produces evidence for subsequent policy decisions". Two conditions are necessary for a novel policy to fall into this category, namely it must test an explicit hypothesis and involve some form of novelty.

Other similar concepts to policy experiments used in the literature are democratic experimentalism and laboratory federalism. The core idea of democratic experimentalism is that many different local units experiment in

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[4] Experiments may even be concentrated within these topics. Castán Broto and Bulkeley (2013) survey climate experiments in 100 cities and find that 30 % relate to urban infrastructure, 25 % to buildings, and about 20 % to urban transport. The same authors note that adaptation experiments account for only 12 % of the urban experiments and carbon sequestration experiments are even rarer.

parallel. Through explicit monitoring and evaluation, one can identify best practices to inform future policies. The concept of laboratory federalism is similar as the main take-away from this literature is that federal systems have a significant advantage over unitary systems because they are composed of local units, which can be used for experimentation. One can loosely understand the theoretical concept of laboratory federalism as innovative public policies introduced in a federal multi-level system that can induce experimentation, learning and competition (Kerber, 2005; Kerber & Eckardt, 2007).

The sandbox concept originated in the domain of financial services, especially in the United Kingdom. The energy sector later adopted the concept, e.g. with Ofgem's sandbox scheme in the United Kingdom. Furthermore, the IEA International Smart Grid Action Network (ISGAN) discusses sandboxes that focus on enabling companies to test new products, services or technologies by providing them with regulatory exemptions.

Instigated by subnational governments, urban laboratories are "mechanisms that mobilize place to generate economic wealth and stimulate more resilient urban conditions, both through the creation of new landscapes and the retrofitting of existing ones" (Evans and Karvonen, 2014, p. 413). Experimentation within urban laboratories involves three key elements, namely situatedness, change-orientation and contingency (Karvonen and van Heur, 2013). The first refers to the existence of some form of border, the second relates to the existence of some dynamic process that involves a 'new rule of conduct' and a 'new definition of the situation' in the sense of Park (1929, p. 17), whereas the last term means that laboratories are always associated with incertitude and the possibility of failure.

Several concepts related to experiments in real-world niches have emerged over recent years in the realm of the transdisciplinary and transformative research agenda (see Schäpke et al., 2017 for an overview and comparison). Here, the role of the regulator regardless of government level is very limited. These experimental concepts include strategic niche management (Hoogma, 2002), transition experiments (Bosch, 2010; Loorbach and Rotmans, 2010), living laboratories/labs (Voytenko et al., 2016; Liedtke et al., 2015), urban transition labs (Nevens et al., 2013), social innovation labs (Westley et al., 2014), and real-world laboratories (Schneidewind and Singer-Brodowski 2013; Schäpke et al. 2017; WBGU 2016).

The real-world laboratory concept in particular has captured regulators' attention in Germany. A recent report commissioned by the German Federal Ministry for Economic Affairs and Energy[5] considers real-world laboratories as experimental areas – which are delimited in time and space as well as legally protected – that permit testing the interplay between innovation and regulation under real-world conditions (BMWi, 2019). In their understanding of the concept, the regulatory component concerns only investigating the rules and regulations needed for a given new technology. A selection of their examples of 'Reallabore' used for illustrative purposes includes testing an automatised parcel delivery robot in the city of Hamburg, testing a platform for remote medical services in the German region of Baden-Württemberg and testing autonomous cars in the capital Berlin.

Finally, legal sociologists conceptualize a 'reflexive law' as an instrument to trigger regulatory innovation by integrating and enabling modes of societal self-organization (Teubner, 1984; Aalders and Wilthaagen, 1997). This strand of literature focuses the adaptation of regulation to the functional demands of the sector to be regulated. Otherapproaches analyse regulatory experiments to determine whether the social objective pursued by a regulation is sufficiently aligned with values and norms of the actors whose behaviour it aims to influence (Heldeweg, 2017; Carbonara et al. 2008). Heldeweg (2017) illustrate the importance of this knowledge-gain before implementing large-scale programs in the context of renewable energy transition. He describes a case of a shared solar program by large economic actors, where contrary to the regulatory goal to expand access to solar incentives to excluded groups; the scheme became a vehicle for the recruitment of corporate or other large-scale subscribers looking to find a hedge against future energy price increases. This focus on the factual effects of norms and goal- or value-oriented norm-interpretation links this empirical literature to legal theoretical studies which conceptualize the conditions for innovations "in the law". New regulations or even (basic) norms thus can be understood as legal reactions to new normative challenges related to societal or economic disruptions (Hoffmann-Riem, 2017).

Distinguishing between various approaches to experimentation in the social sciences

It is useful to take a closer look at the differences and similarities between the different concepts for the act of experimenting with regulation. According to Huitema et al. (2018), the most important differences between the various approaches to policy experimentation are whether experimentation is one specific method or a composition of several type of methods, as well as the extent to which they require a strict experimental design as well as solely quantitative data collection (Huitema et al., 2018).

For the purpose of this paper, we propose a new way of distinguishing between the various concepts for experimentation encountered in the social sciences according to a number of key characteristics. The first characteristic

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[5] The same ministry has launched a network for real-world laboratories ('Reallabore'). Website (in German): https://www.bmwi.de/Redaktion/DE/Dossier/reallabore-testraeume-fuer-innovation-und-regulierung.html .

of 'sustainability relevance' reflects to the extent to which the concept relates to our broad understanding of sustainable development in accordance with the UN SDGs. Irrespective of this, an experiment can test sustainable solutions defined more narrowly, i.e. promoting green innovations captured by the second characteristic of 'green objectives'.

The presence of some form of regulatory object constitutes a minimum criterion for us to consider a concept as a regulatory experiment, since this paper is about governance. The characteristics of 'presence of regulatory object' and 'presence of technological object' depict the extent to which the experimental concept is relevant for testing out regulatory options and/or technological innovations.

According to Bulkeley et al. (2014), actors besides the national regulator – such as subnational governments, non-governmental organisations, businesses and individuals – are increasingly initiating their own experiments. These non-regulatory stakeholders may also play an important role in experiments initiated by the regulator. 'Regulatory control' captures the extent to which the regulator influences the initiation of the experiment and how the experimental process unfolds over time.

The characteristic of 'inclusiveness' relates to the scope of the regulatory object and captures the extent to which the given concept involves a variety of stakeholders. A higher variety of stakeholders usually involves higher transactions costs, although it can ensure a broader consensus about the usefulness of the experiment. Finally, 'specificity' refers to whether the concept entails a precise definition and understanding an experiment, in order to differenciate between policies that have an experimental character and those that do not.

We now briefly discuss the similarities and differences between the concepts of policy experimentation, democratic experimentalism, sandboxes, urban laboratories, real-world laboratories, and regulatory innovation zones and our unstanding of regulatory experimentation in relation to these criteria (see table 1 for a characterisation).

Table 1. Characterisation of concepts for experimenting with regulation

	Sustainability relevance	Green objectives	Presence of regulatory object	Presence of technological object	Regulatory control	Inclusiveness	Specificity
Policy experimentation	++	0	+	-	0	+	0
Democratic experimentalism	++	-	+	-	0	+	0
Laboratory federalism	++	-	++	--	0	+	0
Sandboxes	++	0	0	++	-	-	0
Urban laboratories	++	++	+	-	0	+	+
Real-world laboratories	++	++	0	+	0	+	0
Real-world laboratories (BMWi)	++	0	++	++	+	+	0
Regulatory innovation zones	++	++	++	--	+	+	+
Regulatory experimentation (authors' concept)	++	++	++	0	++	++	+

++=very high, +=high, 0=moderate, -=low, --=very low

For 'policy experimentation', no common understanding exists, but our criteria from above can help to show how policy experimentation differs from other forms of experimentation. Although the concept of policy experimentation describes several climate- and environmental-related experiments, promoting green innovations is not a distinguishing feature. Policy experiments involve a variety of actors in the experimental process indicating a high degree of inclusiveness. Since the responsibility for executing the experiment is not specified (McFadgen and Huitema, 2018), regulatory control remains moderate. The main object of policy experiments is regulatory and not technological.

The concept of democratic experimentalism is moderately specified because it considers several decentralised forms of coordination in diverse settings (Dorf and Sabel, 1998). Thus, green development is only one field of application of democratic experimentalism. Including several actors in different subnational units is characteristic for democratic experimentalism. Democratic experimentalism has mainly a regulatory instead of a technological object. Nevertheless, its decentralised character might result in only moderate regulatory control. Federal experimentalism has no explicit connection to green development. The concept says little about inclusiveness. The object of this concept is explicitly regulatory and not technological. Since federal entities are responsible for introducing policies, regulatory control remains moderate.

Sandboxes moderately specify their objects of consideration, which can be innovative product, service or business models (Ofgem, 2018). Over time, the concept has become more relevant in fields like the energy sector where green development goals are central. The degree of inclusiveness is limited because individual firms often test innovations by exploiting exemptions provided by the regulator. The object is technological rather than regulatory although the regulator is interested in discovering the best regulatory responses to future technical developments. Regulatory control mainly occurs by way of applying an exemption clause, and remains low during the experimentation process.

Urban laboratory is a specified concept as it relates to experiments conducted within given geographic boundaries (cities) (Evans and Karvonen, 2014). Green innovation goals – for example, reducing carbon emissions – are common to urban laboratories. They generally include many stakeholders such as policy-makers, researchers and practitioners. The aim of urban laboratories is not to test (sustainable) technologies but rather to produce knowledge about green developments and serve as a method for experimental governance. Hence, their object is primarily regulatory.

Different conceptualisations of real-world laboratories exist. One of them relates to sustainability transformation research (e.g. Schäpke et al., 2018) and it moderately specifies which cases fall under this concept, since the concept encompasses social, cultural, technical, economic as well as other sustainability-related innovations (Parodi, 2019). As a result, green objectives are highly relevant for this concept of real-world laboratories. Since transdisciplinary research as well as the involvement of societal stakeholders characterise this concept, its degree of inclusiveness is high. As already highlighted, objects of real-world laboratories can be diverse and do not explicitly focus on regulations. Due to the diverse types of testable innovations and the inclusiveness, regulatory control remains moderate.

The real-world laboratory concept of the Federal Ministry for Economic Affairs and Energy in Germany (BMWi, 2019) differs from the previous conceptualisation in several aspects. First, it focuses on the temporary and often spatially limited test of innovations and regulations. Thus, these experiments are moderately specified. Second, this concept of experimentation focuses on the broad topic of digitalisation and not specifically on green development. From this perspective, real-world laboratories have a high degree of inclusiveness, as the current conceptualisation highlights the importance of identifying all related actors for executing an experiment. The object can be both regulatory as well as technical innovations, although technical innovations seem to be predominant. In addition, the regulatory knowledge gain sought is limited to adopting the regulatory framework to new technologies and is not concerned with initiating and accompanying sustainable transformation processes. Regulatory control remains rather high because experimentation clauses for firms are explicitly limited in time and space and aim to improve existing regulation.[6]

The concept of regulatory innovation zones (RIZs) clearly specifies what an experiment is, since it must be temporarily and spatially limited (Bauknecht et al. 2015). Achieving green development goals is very important to RIZs, which mainly concern the field of energy transition. They have a high degree of inclusiveness because the implementation of RIZs aims to include all relevant actors. The object of the concept is explicitly regulatory and not technological and requires a high degree of regulatory control.

As our work aims to provide actors with guidelines to experimentation based on existing evidence of experimentation, we favour a broad understanding of the concept of regulatory experimentation. Since our purpose is to describe real cases and develop a framework for analysis, we consider the disadvantage of including less relevant cases in our analysis to be much smaller than the disadvantage of excluding relevant ones. As a result of this – and not because our understanding is in any way better than the others - our concept of regulatory concept stands out by a very high score on most characteristics.

To summarize, all of the above experimental approaches received a high score on sustainability relevance. This reflects our starting assumption that sustainable development implies reflexive governance and experimentation. The overview however also shows clear differences between the concepts. For instance, democratic experimentalism and laboratory federalism are clearly theoretical concepts that discuss how the political system can induce

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[6] In cases where experimentation clauses are used to allow for testing innovations, regulatory control during the experimentation process is low. However, when specific regulations are object of the experiment, a high degree of regulatory control is necessary. Accordingly, we decided to assign a high value of regulatory control to the concept.

experimentation. By contrast, sandboxes, real-world laboratories and RIZs emerged from applied projects. Finally, we emphasize that these conceptual differences have a positive – not a normative – character.

4   Challenges for regulatory experimentation in practice

Despite the potential advantages of experimentation highlighted in part two of this paper, the use of regulatory experiments faces several hurdles. To ensure that experiments lead to the desired knowledge gain, it is important to keep them in mind when designing experiments.

As politicians care about re-election, it is unlikely that they will risk regulation potentially leading to a large loss of votes. Public acceptance poses an important challenge for regulatory experimentation. Greenstone (2009, p. 121) notes that "people frequently have a visceral reaction against experiments that involve humans". To address this problem, he suggests developing a code of ethics for all regulatory experimentation. Furthermore, individuals may be able to overcome such inherent disapprobation if they are offered a pecuniary benefit from it. Orcutt and Orcutt (1968) emphasise that incentive regulations lend themselves best for experimentation because by design every participant can make a net gain.

Greenstone (2009, p. 17) also notes that "some consider randomized experiments unethical, because they relegate a significant number of people to the control group when there are non-experimental reasons to believe that the treatment will prove beneficial". In a similar vein, other authors have highlighted that experiments are not neutral and they affect various groups in the population differently, which consequently affects the political dynamics surrounding experimentation (Huitema et al., 2018).[7] For this reason, political communication about social benefits plays an important role. Emphasising the advantages of reflexive governance could enhance the public acceptance of experimentation. Orcutt and Orcutt (1968) argue that even experimentation that can be potentially dangerous for the treatment group can gain acceptance if the public regards the research objective as socially important. It could also be helpful to remind the public that regulators such as the Federal Drug Administration in the US already undertake experiments and that most would find it unacceptable that an untested drug should be available on the market.

Another important challenge of experimentation is that regulators must acknowledge that there is uncertainty tied to the outcome of a particular policy measure. Politicians rarely communicate uncertainty and are usually better off if they emphasise profound knowledge about future development towards voters. Instead, engaging in regulatory experimentation presupposes curiosity to investigate potential outcomes to lift this uncertainty.

Orcutt and Orcutt (1968) emphasise costs as an important barrier to experimentation. The authors highlight that costs are driven upwards by the fact that experiments must be of a certain scale (in terms of both time and space) to produce regulatory learning and because there must be some form of compensation to encourage participation. The authors propose several ways to reduce the costs of experimentation: (1) starting with a smaller number of participants and then increasing participation until obtaining the desired precision of results (sequential experimentation); (2) undertaking several experiments simultaneously and using the same control group, with joint use of experimental treatments by monitoring several observational variables of interest to different stakeholders; and (3) exploiting economies of scale by using the same infrastructure (specialists, field staff and facilities) for executing different experiments.

Another challenge of regulatory experimentation is to generate valid regulatory learning, i.e. correctly linking cause and effect. This is often associated with methodological challenges since a regulatory experiment does not have controlled laboratory conditions. Issues related to the causality of evaluated effects (internal validity) will probably arise, the extent of which primarily hinges on the quality of the control group. Another issue may be the universality of effects (external validity), which depends on treatment randomisation. In addition, other factors such as local institutions – which are by nature context-specific and rather constant over time – can affect the outcomes of experiments. Finally, learning must involve all stakeholders and evaluations and publications must show the results of the experiment even if they do not show socially-desired results.

Regulatory experimentation also faces legal challenges. Since regulatory experiments involve "real-life" actors, regulators need to take into account national and supranational law. Specific legal questions may arise with respect to concrete experiments – challenges for regulatory experiments will differ depending on the experimental setup and the respective areas of law. For the German context, BMWi (2019) provides some specific examples of legal obstacles such as the interdiction for doctors to treat patients exclusively via communication media. In contrast, the following aspects refer to more general requirements that are to be taken into account. These general legal aspects will be – to varying degrees – relevant in most legal systems. The analysis will focus concepts in German legal doctrine, where deemed necessary.

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[7] Several empirical studies of experiments have highlighted such distributional effects (e.g. Hoffmann, 2011; Castan Broto and Bulkeley, 2013; and Doherty et al., 2016). For instance, in their survey of urban climate change experiments, Castan Broto and Bulkeley (2013) find that environmental justice was a pronounced concern in 25 % of the cases.

Such general challenges prominently result from the principle of the rule of law. The rule of law[8] on the one hand can prohibit regulatory experimentation in densely regulated fields of law, because deviations of the existing regulatory framework might not be permitted. For example, Missling et al. (2016) assert that German and European Energy Law do not permit temporal and geographical exceptions from the general rules. Every experiment with innovative rules in this area accordingly would require the adaptation of the respective laws by the legislator.

The rule of law also stipulates, that significant decisions, i.e. those of substantial weight for the commonwealth, require parliamentary approval (s. BVerfGE 47, 46 (78f.).[9] Essential questions regarding legal policy consequently have to be regulated in a formal statute. Such essential questions prominently are concerned when a regulation encroaches in the exercise of a basic right. The requirement of a parliamentary law to authorize administrative actions thus can constitute an obstacle for flexible experimentation by the administration.[10] Even if such a law exists, general formulations to authorize regulatory experiments might be regarded insufficient to comply with the principle of reservation of the law. In cases of potential encroachments on basic rights the principle of reservation to the law finally may also imply a "prohibition of delegation" regarding the authorization of the administration to enact statutes or regulations, (Hoffmann-Riem, 2005, p. 52).

A third challenge related to the rule of law is the principle of legal certainty, which requires that a statutory authorization of the executive branch must be sufficiently defined and limited in content and purpose. In the German context, general clauses that allow for some regulatory leeway are generally admissible. However, basic limitations for the authorities` actions have to be defined in the law (BVerfGE 108, 52, 75). The required clarity and determinedness of these limitations depends on the intensity of potential encroachments of constitutional rights. The principle of legal certainty also implies that the law provides stringent regulatory objectives (Pieroth, 2014).

Independently of implications for the requirement of parliamentary approval, legal experimentations have to consider if they infringe basic rights. For instance, legal experimentations must also consider the principle of equality, which prohibits arbitrary unequal treatment. It gets more stringent, the more (groups of) individuals are concerned, and it leaves more leeway for legislation when it targets the design of general living conditions (BVerfGE 88, 87, 96 f.).

Accordingly, the principle is less demanding, if the unequal treatment of diverse groups of persons is untended, but only factual circumstances are treated unequally. In such cases only arbitrary differences in treatment infringe the principle of equality; every reasonable consideration constitutes a justification for differentiation. If it is justifiable, the legislature may in principle also deviate from rules itself has enacted (Kahl et al., 2016). Overall, it seems unlikely that regulatory experiments would fail because it is not possible to justify an unequal treatment (Missling et al. 2016). The requirement to balance the objective of the regulatory experiment and potentially affected rights however illustrates the need for a clear definition of the goals of a regulatory experiment.

In conclusion to the legal challenges, it is important to note that legal flexibilities and obstacles for regulatory experimentation will differ depending on the national and supranational law, the experimental setup and the respective areas of law. Hence, the experimenter should determine the legal areas and specific laws that are relevant for the regulatory experiment (Brandt et al., 2019). Then, experimenters must identify potential rules providing the necessary regulatory leeway before choosing the experimental design.

5   Analysing regulatory experiments

While the previous sections provided a characterisation of various experimental approaches such as policy experiment, democratic experimentalism, etc. and described the core challenges to regulatory experiments, this section provides a comprehensive framework for describing experiments in detail. Along the four core features of regulatory experiments – (1) clear hypothesis, (2) interaction between actors, (3) causality, and (4) monitoring and learning – we outline a number of variables that any analysis of regulatory experiments should include.

The literature has already attempted to categorise different types of policy experiments. Starting from the most general typology, Huitema et al. (2018) distinguish between approaching policy experimentation as a research method and an approach to governance. As a research method, experiments are treatments seeking to produce causality though randomisation and statistical analysis. As an approach to governance, experimentation is a means to test several options when solving societal problems and to develop regulation in practice in order to draw plausible conclusions from it (=learning).

Ludwig et al. (2011) distinguish between policy evaluations and mechanism experiments. Policy evaluations test the effect of a certain policy by implementing it on a small scale using randomisation procedures to form

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[8] In German legal doctrine this aspect is addressed by the principle of primacy of the law (Vorrang des Gesetzes) as an element of the rule of law (Rechtsstaatsprinzip).

[9] German legal doctrince addresses this aspect by the principle of reservation of the law (Vorbehalt des Gesetzes) as an element of the rule of law (Rechtsstaatsprinzip).

[10] This legal problem can be adressed by means of experimentation or flexibility clauses.

treatment and control groups. Mechanism experiments focus on discovering specific causal mechanisms that link a policy to given outcomes.

Howe (2004) distinguishes between two forms of 'experimentalism', namely neoclassical and mixed methods. The former relies exclusively on quantitative methods, whereas the latter opens up for the use of qualitative evaluation methods.

Ansell and Bartenberger (2016) distinguish between three experimental logics: controlled (identifying causality ideally in randomised controlled trials), Darwinian (enhancing systemic innovation through continuous trial and error) and generative (process of generating and iteratively refining a solution to a social problem).

Finally, experiments have also been categorised according to one specific feature; for instance, based on the role of science in policy-making (Pielke Jr., 2007), governance design (Weber, 1968; and Dryzek, 1987) and learning outcomes, McFadgen and Huitema (2018).

While all of these are important contributions, they only look at a limited number of variables defining experiments. Therefore, in our view they are only partial categorisations and thus they are incomplete in serving as a tool for surveying and analysing regulatory experiments. For an in-depth analysis of regulatory experiments, the framework should identify core variables of experiments and enable comparisons.

Hence, in the following, we outline a new conceptual framework that describes existing regulatory experiments in a profile sheet based upon our four criteria of regulatory experimentation. Both for hypotheses testing, participation, causal framework, and learning/monitoring, we define variables that are the features of regulatory experiments within each category that we consider to be relevant. For each variable, we further define which form a given regulatory experiment can take. Depending on the specific variable, characteristics can have the form of either yes or no answers, numbers, two or more possible answers that do not necessarily have to be mutually exclusive, and can even be an open question.

Test of explicit hypotheses

The first part of the profile sheet depicts aspects of regulatory experiments related to hypotheses testing. More precisely, the variables specify the aim, object and SDG orientation of the experiment, the controllability of the experimental process and finally whether the experiment serves to falsify specific hypotheses. Figure 1 depicts each of the variables on 'testing explicit hypotheses'.

Figure 1. Variables for testing explicit hypotheses
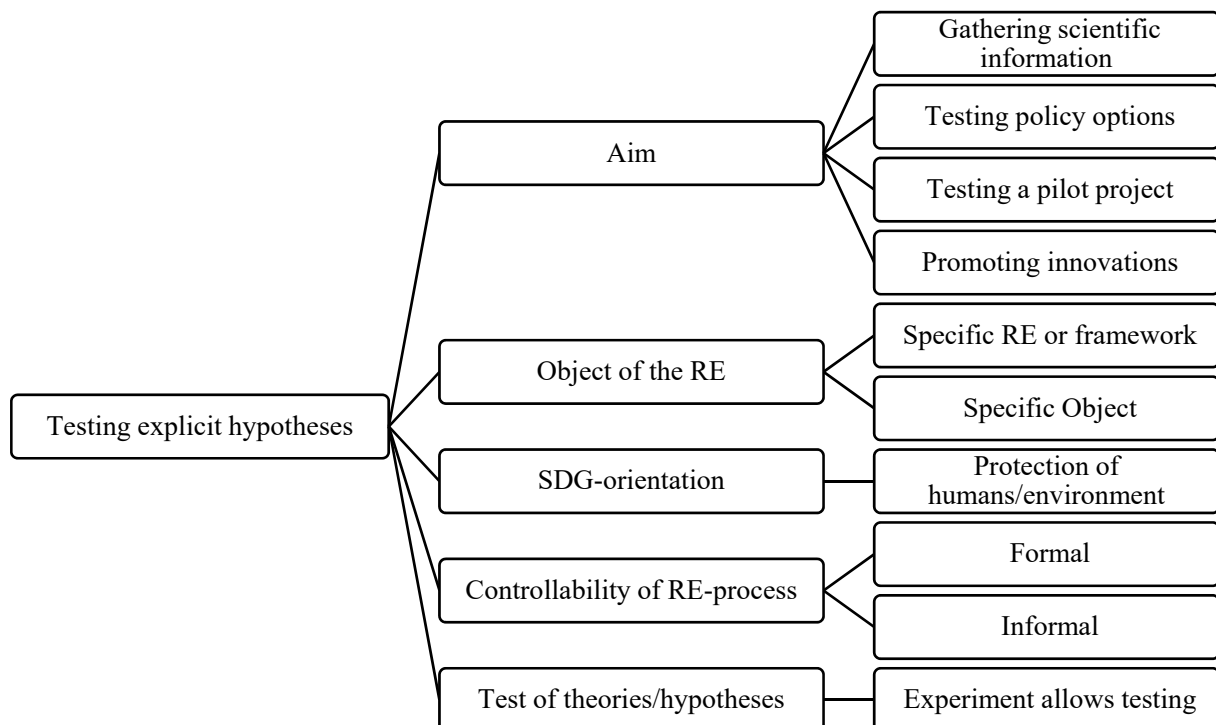
The variable 'aim' captures the overall purpose of the experiment. Based on McFadgen and Huitema (2018), our profile sheet differentiates between the aims to 'gather scientific information', 'test policy options' and 'test a pilot project'. We add a fourth aim of 'promoting innovations' since most experiments relate to innovations (Bernstein & Hoffmann, 2018). Löher and Schneck (2018) argue that firm-initiated real-world laboratories can offer the

opportunity to test innovations and their social acceptance. This element might be also relevant for regulatory experiments.

The variable 'object of the regulatory experiment' specifies what is explicitly considered in the experiment and it is divided into two questions. The first question reveals whether the experiment describes a specific experiment or whether it is a framework for several experiments. The second question asks for a detailed description of the object. As our approach to regulatory experimentation focuses on its contribution to sustainable development, we include the variable 'SDG orientation', which illustrates whether the regulatory experiments aims at a high level of protection for humans and the environment by identifying (when present) SDG goals in accordance with the aim of the regulatory experiment.

The variable 'controllability' illustrates the degree of formality of the experimental approach, which is important for testing explicit hypotheses. Existing experiments in voluntary commitment systems in the field of climate governance inspire the distinction between 'formal' and 'informal' experimentation (see e.g. Abbott, 2017). In formal experiments, the experimental design lives up to scientific standards as far as it is possible in real-world contexts. This is not the case for informal experiments, which may also arise without an explicit experimental intention from the regulator.

Finally, the variable 'test of theories/hypotheses' evaluates whether the regulatory experiment has led to an explicit refutation of hypotheses and theories being tested and is characterised by a simple 'yes' or 'no'.

Interaction between different actors

The second part of the profile sheet examines the interaction between actors participating in the regulatory experiment. It covers who initiated the experiment, which actors participated at the implementation of the experiment and controls whether the composition of actors has changed during the experiment. Figure 2 depicts each of the variables profiled in the 'interaction between different actors' part.

Figure 2. Variables of the part interaction between different actors
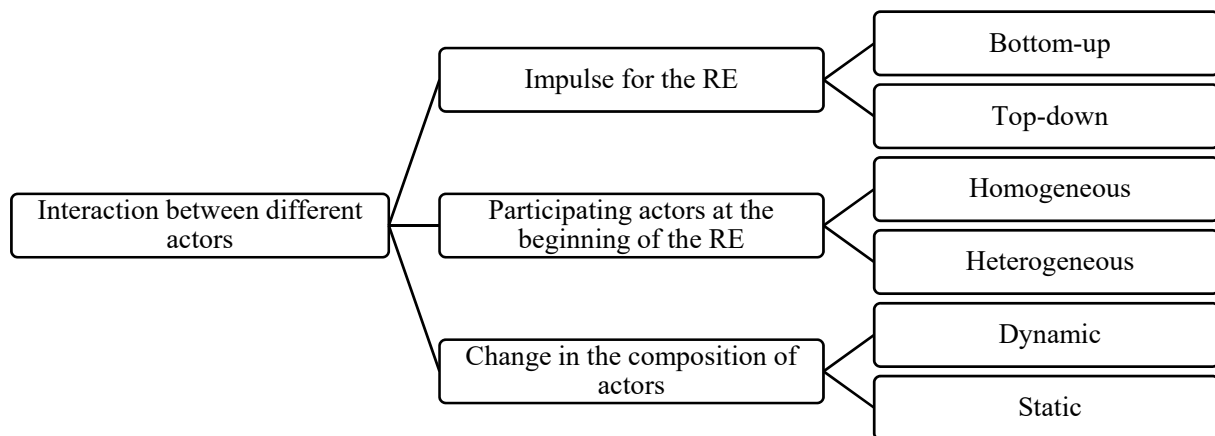
The variable 'impulse' depicts how the regulatory experiment came about. Here, we want to capture whether the experiment originated as a top-down or a bottom-up process. Regulations form the institutional framework within which market actors operate. How they are shaped will hence influence innovation incentives and capacities in the market. Vice versa, individual behaviour and market developments determine the needs and outcomes of regulations. In the case of top-down governance, the regulator can adjust the institutional framework to influence individual behaviour. Inversely, bottom-up governance processes materialise when firms try to alter the national institutional setup if it does not suit their needs (Crouch et al. 2009).

The literature supports mapping out relevant actors in experiments. Castán Broto and Bulkeley (2013) analyse the mix of heterogeneous actors in urban climate change experiments. Additionally, McFadgen and Huitema (2018) argue that different actors can initiate policy experiments: an expert elite seeking scientific knowledge (technocratic experiment), a collaboration of actors developing different policy options (boundary experiment), an organiser (often policy-makers) and other actors with the same problem perception wanting to establish particular actions (advocacy experiment).

Therefore, the next two variables cover the type of actors involved in the regulatory experiment and possible dynamics in their composition based on the work of Simon et al. (2018), who establish criteria to classify different types of real-world laboratories. The variable 'participating actors at the beginning of a regulatory experiment' can take on the characteristics of 'homogeneous' when a single actor initiates the experiment or 'heterogeneous' when a collaboration of different actors stands behind the experiment. The variable 'change in the composition of

actors' focuses on the implementation process of the experiment. The characteristics 'dynamic' and 'static' indicate whether the composition of actors has changed.

Causality

The fourth part of the profile sheet investigates whether the experimental design allows measuring causal effects. Variables in this part capture the geographical scope and time frame of the experiment, as well as several topics addressing the experimental design in detail. Figure 3 depicts each of the variables profiled in this part.

Figure 3. Variables for causality
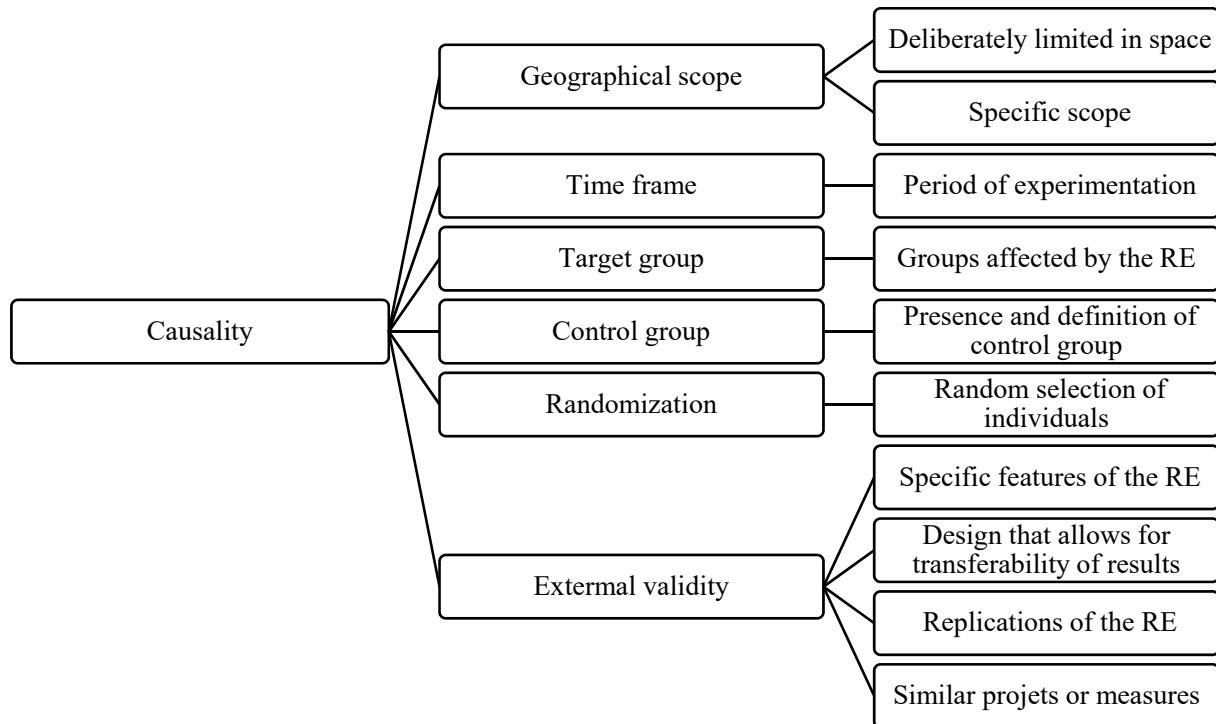
Two questions inform about the 'geographical scope' of the regulatory experiment: whether the experiments was ex-ante deliberately limited in space and which ex-post geographical demarcation characterises the experiment. The latter is an open question because one cannot list all possible geographical scopes. The variable 'timeframe' illustrate how the experiment is limited in time (number of years).

The next variable 'target group' identifies the sub-populations affected by the regulatory experiment. Again, in order to cover all possibilities that may arise in practical applications, this is the answer to the open question 'what is the target group of the regulatory experiment?'.

Our understanding of regulatory experiments implies that some kind of control group is present. The control group can be either explicitly defined ex-ante of the experiment or becomes apparent ex-post. Regardless of whether it was the purpose at the launch of the experiment, in a first step we identify whether a control group exists and in a second step whether it differs from the treated group in time, space or individuals.

In laboratory experiments, researchers use randomisation as an assignment mechanism to define the treatment and control group based on the target population. We suspect that many real-world experiments do not (fully) fulfil this condition, and hence we ask the question 'whether units of observation were selected randomly'.

Finally, an important issue is whether the regulatory learning obtained through an experiment would be the same in different settings (Ludwig et al. 2011; Banerjee and Duflo 2009). We include as the final variable for this part 'external validity of results' in our profile sheet. Four characteristics depict this feature of the experiment. The first characteristic details general features of the experiment that reduce the transferability of results. The remaining three characteristics review design elements that reduce problems of external validity issues, i.e. whether the experimental design allows or simplifies the transferability results, whether it is possible to replicate the experiment, whether replication studies already exist, and finally whether there are other projects or measures that test similar relations. Replication studies or the evaluation of related experiments can help to reduce uncertainty about the external validity of the results (Banerjee and Duflo 2009).

Monitoring and learning processes

The final part of our profile sheet covers the monitoring and learning processes of regulatory experiments. This part specifies how the evaluation of the experiment takes place and the subsequent use of evaluation results. Figure 4 depicts each of the variables profiled in this part.

Figure 4. Variables for monitoring and learning processes
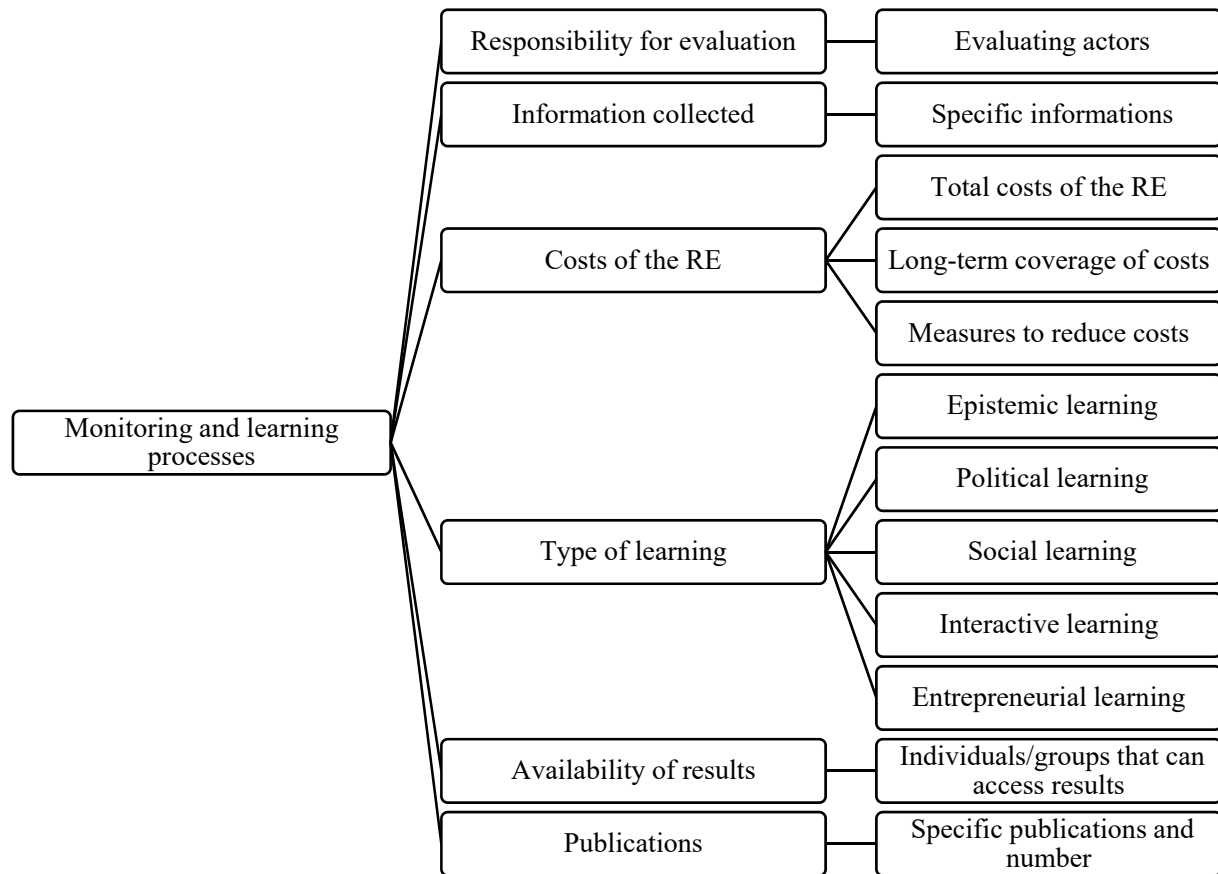
The first two variables collect general information about the evaluation process. The open question 'who is responsible for evaluating the regulatory experiment?' ('no one' being a possible answer here) characterises the variable 'responsibility for the evaluation'. The open question 'which information is collected for evaluation purposes?' (again, 'none' being a possible answer) characterises the second variable 'information collected'.

The next variables concern the costs of the experiment. The 'total costs of the regulatory experiment' sums up the administrative costs in Euro, whereas the characteristics 'is the long-term financing of the experiment covered?' and 'were specific measures undertaken to reduce costs?' (both yes or no as possible answers) illustrate the attention given to costs in the experimental undertaking.

The variable 'type of learning' specifies whether and how insights from the regulatory experiment generate learning processes. The first two characteristics of this variable 'epistemic' and 'political' learning use the distinction of Ansell and Bartenberger (2016), whereby epistemic learning describes the accumulation of scientific knowledge whereas political learning is about changes in the preferences and goals of political actors.

To this typology, we add the characteristic 'social learning' because regulatory experiments can also affect the preferences and goals of societal actors (Rocle and Salles, 2018). In their case study of coastal adaption in France, the authors show that the policy experiment led to increased awareness of the problem among the whole society and created acceptance for experimentation. We also add 'interactive learning', which reflects the notion that regulatory experiments may affects actors' behaviour regarding information acquisition, communication and co-operation. Finally, we add 'entrepreneurial learning' to collect information about how regulatory experiments might affect learning processes in firms, which in turn spark innovation.

The variable 'availability of results' checks with an open question 'who can access the results of the regulatory experiment?'. Finally, the variable 'publications' reveals whether the evaluation process of the regulatory experiment resulted in any publications. This completes our tool to profile specific examples of regulatory experiments.

6   conclusion

The starting premise for this paper was that in the case of sustainable development, the outcomes of policies and regulations are even more uncertain than usual as greater changes are required. Indeed, sustainable development is a complex process with a high degree of uncertainty since it involves many intertwined dimensions, giving rise to trade-offs and unintended side effects. Ex-ante cost-benefit analysis thus becomes difficult to carry out as it rarely involves one policy measure, but rather a sequence of policy measures all of which are dependent on side effects and behavioural responses.

Through trial and error, reflexive governance systems can improve regulation over time and break path dependencies. However, trial and error implies some kind of learning taking place. Thus, learning is key to reflexive governance systems. Reflexive governance comprises both vertical and horizontal regulatory learning processes. This paper adds to the recent suggestions to embed regulatory experimentation as an integral part of governance structures to obtain the knowledge needed for sustainable development.

We have presented an encompassing overview of all concepts related to policy-related experimentation in the social sciences literature and showed some similarities, although also important differences. Building on this, our contribution is a broad approach to regulatory experimentation. Ideally, a regulatory experiment meets the four general conditions: (1) It is possible to use the policy to test clear-cut hypotheses regarding its effects. This can either be the explicit intention from the regulator's side or an implicit cause of the policy design. (2) In order to test this hypothesis, the experiment design addresses the fundamental problem of casual inference, i.e. in some way or another a control group that did not receive a certain treatment is present and ideally the subjects are randomly selected to the treatment and control group. (3) The alternative institutional setup involves cooperation between different societal actors, of which the regulator is an important part. (4) Finally, the experiment enable some form of monitoring and learning.

For all four general conditions, we formulated a total of 22 variables – some of them binary, and some with open questions – to precisely characterise experiments. These variables we summarised in a profile sheet to generally apply to all experiments. The summary can enable improved design of regulatory experiments as the multiple possible dimensions of this tool become clear. If the summary is applied to many regulatory experiments, it will allow a deeper analysis of factors that make experiments more or less successful in inducing learning processes. To our knowledge, it reflects the first categorisation assembling all design aspects of regulatory experiments that need to be considered when operationalising the concept as an integral part of reflexive governance structures.

REFERENCES

Abbott, K. W. (2017): "Orchestrating experimentation in non-state environmental commitments" in: Environmental Politics 26(4), pp. 738–763.

Aalders, M. and Wilthagen, T. (1997): "Moving Beyond Command-and-Control: Reflexivity in the Regulation of Occupational Safety and Health and the Environment", in: Law and Policy 19(4), pp. 415-443.

Ansell, C. K. and Bartenberger, M. (2016): "Varieties of experimentalism", in: Ecological Economics 130, pp. 64–73.

Ayres, I. and Braithwaite, J. (1992): "Responsive Regulation - Transcending the Deregulation Debate". Oxford University Press, New York.

Banerjee, A. V. and Duflo, E. (2009): "The Experimental Approach to Development Economics", in: The Annual Review of Economics 1, pp. 151-178.

Bauknecht, D., Heinemann, C., Stronzik, M. and Schmitt, S. (2015): „Austesten von regulatorischen Innovationen - das Instrument der Regulatorischen Innovationszone", in: Energiewirtschaftliche Tagesfragen 65(7), pp. 61-64.

Becker, E. and Jahn, T. (2000): „Sozial-ökologische Transformationen- Theoretische und methodische Probleme transdisziplinärer Nachhaltigkeitsforschung", in: Brand, K.W.: Nachhaltige Entwicklung und Transdisziplinarität- Besonderheiten, Probleme und Erfordernisse der Nachhaltigkeitsforschung, Analytica, Berlin.

Bernstein, S. and Hoffmann, M. (2018): "The politics of decarbonization and the catalytic impact of subnational climate experiments", in: Policy Sciences 51(2), pp. 189-211.

Bizer, K., Führ, M. and Hüttig, C. (2002): „Responsive Regulierung - Beiträge zur interdisziplinären Institutionenanalyse und Gesetzesfolgenabschätzung". Mohr-Siebeck, Tübingen.

Bizer, K. and Führ, Martin (2015): "Compact Guidelines: Practical Procedure in Interdisciplinary Institutional Analsis". sofia-Diskussionsbeträge 15-4, Darmstadt.

BMWi (2019): "Freiräume für Innovationen- Das Handbuch für Reallabore". Bundesministerium für Wirtschaft und Energi, Berlin.

Bos, J.J. and Brown, R.R. (2012): Governance Experimentation and Factors of Success in Socio-Technical Transitions in the Urban Water Sector", in: Technological Forecasting and Social Change 79(7), pp. 1340-1353.

Bosch, S. van den (2010): „Transition experiments. Exploring societal changes towards sus-tainability". PhD Dissertation, Erasmus Universiteit, Rotterdam. Online (downloaded on 16.07.2017): http://hdl.handle.net/1765/20714

Brandt, J. C., Bullinger, A and Duisberg, A. (2019): "Reallabore als Testräume für Innovation und Regulierung- Ein Leitfaden für Verwaltungen und Unternehmen", in: Potenziale und Anforderungen regulatorische Experimentierräume (Reallabore). VDI Technologiezentrum, Düsseldorf.

Briglauer, W., Vogelsang, I. and Camarda, E. (2017): "Path Dependencies versus Efficiencies in Regulation: Evidence from 'Old' and 'New' Broadband Markets in the EU (October 10, 2017)". Available at SSRN: https://ssrn.com/abstract=3050661 or http://dx.doi.org/10.2139/ssrn.3050661

Bulkeley, H., Andonova, L., Betsill, M., Compagnon, D., Hale, T., Hoffmann, M., Newell, P., Paterson, M. Roger, C. and VanDeveer, S. (2014): "Transnational Climate Change Governance". Cambridge: Cambridge University Press.

Bundesregierung (2016, updated 2017): „Deutsche Nachhaltigkeitsstrategie, Neuauflage 2016", Kabinettsbeschluss 11.1.2017, Berlin.

Campbell, D.T. (1997): "The experimenting society", in: Dunn, W. N. (eds.): The experimenting society. Essays in honor of Donald T. Campell, in: Policy Studies Review Annual 11, pp. 35-68. New Brunswick: Transaction Publishers.

Carbonara, E., Parisi, F. and von Wangenheim, G. (2008): „Legal Innovations and the Compliance Paradox", in: Economic Geography 93(5), pp. 837-860.

Castán Broto, V. and Bulkeley, H. (2013): "A survey of urban climate change experiments in 100 cities", in: Minnesota Journal of Law, Science and Technology 9(2), pp. 92–102.

Doherty, M., Klima, K. and Hellmann, J. J. (2016): "Climate change in the urban environment: Advaning, measuring and achieving resiliency", in: Environmental Science and Policy 66, pp. 310-313.

Dorf, M. C. and Sabel, C. F. (1998): "A Constitution of Democration Experimentalism", in: Columbia Law Review 98(2), pp. 267-473.

Dryzek, J. (1987): "Rational Ecology: Environment and Political Economy". New York: Basil Blackwell.

Evans, J. and Karvonen, A. (2014): "'Give Me a Laboratory and I Will Lower Your Carbon Footprint!'- Urban Laboratories and the Governance of Low-Carbon Futures", in: International Journal of Urban and Regional Research 38(2), pp. 413-430.

Farrelly, M. and Brown, R. (2011): "Rethinking Urban Water Management: Experimentation as a Way Forward?", in: Global Environmental Change 21(2), pp. 721-732.

Fitjar, R.D. and Huber, F. (2015): "Global pipelines for innovations: Insights from the case of Norway", in: Journal of Economic Geography 15, pp. 561-583.

Führ, M. and Bizer, K. (2007): "REACh as a paradigm shift in chemical policy - responsive regulation and behavioural models", in: Journal of Cleaner Production 15(4), pp. 327-334.

Greenstone, M. (2009): "Toward a Culture of Persistant Regulatory Experimentation and Evaluation", in: Moss, David and John Cisternino (eds) New Perspectives on Regulation. Cambridge, MA; The Tobin Project.

Grillitsch, M., Martin, R. and Srholec, M. (2017): „Knowledge Base Combinations and Innovation Performance in Swedish Regions", in: Economic Geography 93(5), pp. 458-479.

Grillitsch, M. and Nilsson, M. (2015): "Innovation in peripheral regions: Do collaborations compensate for a lack of local knowledge spillovers?", in: The Annals of Regional Science 54, pp. 299-321.

Heldeweg, M.A. (2017): "Normative Alignment, Institutional Resilience and Shifts in Legal Governance of the Energy Transition", in: Sustainability 9(1273), pp. 1-34.

Hoffmann-Riem, W. (2017): „Öffentliches Recht als Mittel und Gegenstand von Innovationen". Workshop „Innovation und Vertragsrecht", Berlin 06.04.2017. Online: https://www.law-school.de/fileadmin/content/law-school.de/de/units/unit_affil_riem/pdf/423_Oeffentliches_Recht_als_Mittel_und_Gegenstand_von_Innovationen...27.08.2017_CK_GH__w_hrs_in_Konflikt_stehende_Kopie_2017-10-13_.pdf

Hoffmann-Riem, W. (2005): „Gesetz und Gesetzesvorbehalt im Umbruch – Zur Qualitäts-Gewährleistung durch Normen", in Archiv des öffentlichen Rechts 130(1), pp. 5-70.

Hoogma, R. (2002): "Experimenting for sustainable transport: the approach of strategic niche management". Routledge.

Howe, K. (2004): „A critique of experimentalism", in: Qualitative Inquiry 10(4), pp. 42-61.

Huitema, D., Jordan, A., Munaretto, S. and Hildén, M.et al. (2018): "Policy experiments: core concepts, political dynamics and impacts", in:. Policy Sciences, 51 (2), pp. 143-159.

Jahn, T. and Keil, F. (2016): „Reallabore im Kontext transdisziplinärer Forschung", in: GAIA 25(4), pp. 247-252.

Jarass, H.D. and Pieroth, B. (2014): „Grundgesetz für die Bundesrepublik Deutschland". GG 13. Auflage 2014.

Kahl, H., Hilpert, J. and Kahles, M. (2016): „Experimentierklauseln im Energierecht. Zur rechtlichen Beurteilung von Sondervorschriften für Pilot- und Demonstrationsvorhaben". Stiftung Umweltenergierecht, Würzburg.

Karvonen, A. and Van Heur, B. (2014): „Urban Laboratories: Experiments in Reworking Cities", in International Journal of Urban and Regional Research 38(2), pp. 379-392.

Kerber, W. (2005): "Applying evolutionary economics to public policy: the example of competitive federalism in the EU", in K. Dopfer (ed.), Economics, Evolution and the State: The Governance of Complexity, Cheltenham, Edward Elgar, pp. 296–324.

Kerber, W. and Eckardt, M. (2007): "Policy learning in Europe: the open method of co-ordination and laboratory federalism", Journal of European Public Policy (14)2, pp. 227-247.

Ledyard, J.O. (1994): "Public Goods: A Survey of Experimental Research," Public Economics 9405003, University Library of Munich, Germany, revised 22 May 1994.

Li, H. and Van Ryzin, G. G. (2017): "A Systematic Review of Experimental Studies in Public Management Journals", in: James, O., Jilke, s. and Van Ryzin, G. G. (eds): Experiments in Public Management Research- Challenges and Contributions. Cambridge University Press, Cambridge.

Liedtke, C., Baedeker, C., Hasselkuß, M., Rohn, H. and Grinewitschus, V. (2015): "User-integrated innovation in Sustainable LivingLabs. An experimental infrastructure for researching and developing sustainable product service systems", in: Journal of Cleaner Production 97, pp. 106–116.

Loorbach, D. and Rotmans, J. (2010): "The practice of transition management. Examples and lessons from four distinct cases", in: Futures 42(3), pp. 237–246.

Löher, J.A. and Schneck, S. (2018): „Denkpapier: Potenziale der Reallaborforschung für die Wirtschaftspolitik". Denkpapier, IfM Bonn.

Ludwig, J., Kling, J. R. and Mullainathan, S. (2011): "Mechanism Experiments and Policy Evaluations", in: Journal of Economic Perspectives 25 (3), pp. 17-38.

Maaß, V. (2003): „Experimentierklauseln für die Verwaltung und ihre verfassungsrechtlichen Grenzen". Duncker & Humblot, Berlin.

Malmberg, A. (1996): „Industrial geography: Agglomoration and local milieu", in: Progress in Human Geography 20(3), pp. 392-403.

McDermott. R. (2002): "Experimental methods in political science", in: Annual Review of Political Science 5, pp. 31-61.

McFadgen, B. and Huitema, D. (2018): "Experimentation at the interface of science and policy: a multi-case analysis of how policy experiments influence political decision-makers", in: Policy Sciences 51(2), pp. 161-187.

Missling, S., Lange, H., Michaels, S. and Weise, M. (2016): „Gutachterliche Stellungnahme zum Instrument einer Regulatorischen Innovationszone". Report commissioned by the Ministry of the Environment, Climate Protection and the Energy Sector in the region of Baden-Württemberg, online: https://um.baden-wuerttemberg.de/de/energie/versorgungssicherheit/smart-grids/gutachten-riz/

Modell, S., Jacobs, K. and Wiesel, F. (2007): "A process re(turn)?: Path dependencies, institutions and performance management in Swedish central government", in: Management Accounting Research 18(4), pp. 453-475.

Munaretto, S. and Huitema, D. (2012): "Adaptative Comanagement in the Venice Lagoon? An Analysis of Current Water and Environmental Management Practices and Prospects for Change", in: Ecology and Society 17(2), pp. 1-16.

Nevens, F., Frantzeskaki, N., Gorissen, L. and Loorbach, D. (2013): „Urban Transition Labs. Co-creating transformative action for sustainable cities", in: Journal of Cleaner Production 50, pp. 111–122.

Ofgem (2018): "What is a regulatory sandbox?" online: https://www.ofgem.gov.uk/publications-and-updates/what-regulatory-sandbox.

Orcutt, G. H. and Orcutt, A. G. (1968): "Incentive and Disincentive Experimentation for Income Maintenance Policy Purposes", in: The American Economic Review, 58(4), pp. 754-772.

Park, R.E. (1929): "The city as social laboratory", in: Smith, T.V. and White, L. D. (eds.): Chicago: An experiment in social science research. University of Chicago Press, Chicago, IL.

Parodi, O. (2019): "Wider eine Engführung des Reallabor-Konzepts", in: Ökologisches Wirtschaften 34(2), pp. 8-9.

Pielke, R.A. (2007): "The honest briker: Making sense of science in policy and politics". Cambridge, Cambridge University Press.

ProClim (1997): "Forschung zu Nachhaltigkeit und Globalem Wandel- Wissenschaftspolitische Visionen der Schweizer Forschenden". Konferenz der Schweizerischen Wissenschaftlichen Akademien. Forum für Klima und Global Change Schweizerische Akademie der Naturwissenschaften.

Radaelli, C. M. (2009): "Measuring policy learning: Regulatory impact assessment in Europe", in: Journal of European Public Policy 16(8), pp. 1145-1164.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. and Foley, J.A. (2009): "A safe operating space for humanity", in: Nature 461, pp. 472–475.

Rocle, N. and Salles, D. (2018): "'Pioneers but not guinea pigs': experimenting with climate change adaptation in French coastal areas", in: Policy Sciences 51(2), pp. 231-247.

Schäpke, N., Stelzer, F., Caniglia, G., Bergmann, M., Wanner, M., Singer-Brodowski, M, Loorbach, M., Olsson, P., Baedeker, C. Lang, D. J. (2018): "Jointly Experimenting for Transformation? Shaping Real-World Laboratories by Comparing Them", in: GAIA-Ecological Perspectives for Science and Society 27(1), pp. 85-96.

Schäpke, N., Stelzer, F., Bergmann, M., Singer-Brodowski, M., Wanner, M., Caniglia, G. and Lang, D. J. (2017): „Reallabore im Kontext transformativer Forschung. Ansatzpunkte zur Konzeption und Einbettung in den internationalen Forschungsstand", in: IETSR Discussion Papers in Transdisciplinary Sustainability Research.

Schneidewind, U. and Singer-Brodowski, M. (2013): „Transformative Wissenschaft. Klimawandel im deutschen Wissenschafts-und Hochschulsystem". Metropolis Verlag, Marburg.

Schwarting, G. (2003): „Von der Experimentierklausel zur Standardöffnung – ein neuer Weg der Vorbereitung von Rechtsvorschriften?". Available online at: https://www.uni-speyer.de/files/de/Studium/Lehrende/Schwarting/aufsatz8.pdf

Simon, D., Korniek, R. L., Straßheim, H., Jarzebski, S., Hengstermann, C., Hausmann, J. and Streiter, F. (2018): „reallabore- Eine neue Form der experimentellen Politikberatung". Stiftung Mercator GmbH and Wissenschaftszentrum Berlin für Sozialforschung GmbH.

Teubner, G. and Willke, H. (1984): „Experimentierklauseln im Energierecht Zur rechtlichen Beurteilung von Sondervorschriften für Pilot- und Demonstrationsvorhaben", in: Zeitschrift für Rechtssoziologie 5(1), pp. 4–35.

United Nations (2008): "Building Trust Through Civic Engagement". Publication based on the 7th Global Forum workshop on building trust through civic engagement in Vienna, Austria. United Nations, New Work.

Vang, J and Chaminade, C. (2007): "Cultural clusters, global-local linkages and spillovers: Theoretical and empirical insights from an exploratory study of Toronto's film cluster", in: Industry and Innovation 14, pp. 401-420.

Voss, J.-P., Kemp, R. and Bauknecht, D. (2006): "Reflexive governance: a view on an emerging path", in: Voss, J-P., Bauknecht, D. and Kemp, R. (eds) Reflexive governance for sustainable development. Cheltenham: Edward Elgar, pp. 419–437.

Voytenko, Y., McCormick, K., Evans, J. and Schliwa, G. (2016): "Urban living labs for sustainability and low carbon cities in Europe. Towards a research agenda", in: Journal of Cleaner Production 123, pp. 45–54.

WBGU (2016): "Humanity on the move. Unlocking the transformative power of cities. Flagship Re-port 2016". German Advisory Council on Global Change.

Weber, M. (1968): "Economy and Society: An Outline of Interpretative Sociology". New York: Bedminister Press.

Westley, F., Antadze, N., Riddell, D.J., Robinson, K. and Geobey, S. (2014): "Five Configurations for Scaling Up Social Innovation", in: The Journal of Applied Behavioral Science 50(3), pp. 234–260.

WCED (1987): „Our Common Future: Report of the UN World Commission on Environment and Development", Oxford University Press, Oxford.

Zelmer, J. (2003): "Linear Public Goods Experiments: A Meta-Analysis", in: Experimental Economics 6, pp. 299-310.