The Governance of Change in Socio-Technical and Innovation Systems: Three pillars for a Conceptual Framework

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2.1 Introduction: Three pillars for a conceptual framework

The previous chapter reviewed succinctly the implicit views on governance in the vast literature dedicated to socio-technical change, identified the research gaps associated with conceptual indeterminacy, and clarified and defined a workable notion of 'governance of change in innovation and socio-technical systems'. In this chapter we turn to the exercise of preliminarily developing what we see as a basis for a conceptual framework. With this purpose in mind, we suggest focusing on three pillars: the opportunity structures and capable agents in a system, the instrumentation of governance of change, and the legitimacy and acceptance of change. The reader might immediately ask: why these three and not others? Naturally, this precise line up and combination of pillars is a subjective choice from our side. However, we have two overall arguments for this choice. First, while all three items or pillars can be found already in the literature in various forms, they have never been defined together as part of a consolidated analytical framework focused on the governance of change. Bringing them together not only makes the existing different dimensions of this complex phenomenon of system change more explicit, but gives emphasis to specific axioms that have rarely been put forward and upon which these previous studies are based. We do not imply that all different approaches can be simply juxtaposed. Instead, we aim at putting forward a consistent conceptual framework which allows us to focus on a limited number of dimensions that we think are crucial to understanding the governance of change. Secondly, and perhaps most relevant for our endeavours, the three pillars together provide a comprehensive view of the key

'governance'-related research question about how system change is coordinated in complex contexts, i.e. what are the modes and actors of coordination. The first and second pillars focus on the actual action of the governance of change (opportunity structures and capable agents, as well as instrumentation), the 'who' and 'how' of governance. The third pillar refers to the popular views and support of the socio-technical system (or lack thereof), and to the process of governing change.

The first pillar of our theoretical endeavour deals (a) with the opportunity structures which are offered by the interplay of a specific institutional set-up in a system on the one hand, and new technologies and knowledge on the other hand; and (b) with agents' capacity to navigate in complex contexts and align positions for a system change. This relates to the perennial agency-institution interaction within a system, which is particularly important in processes of governing system change. The second pillar is the governance instrumentation in processes of change of socio-technical systems. The notion 'governance' brings forward the understanding that collective action entails complex forms of public-private interactions. These interactions are typically conceptualized as 'governance instruments', which have the explicit intention to shape social action in specific ways. Under this prism, governance instruments are the mechanisms put forward by different sets of actors in order to achieve specific goals and therefore are a concretization of the overall opportunity structures mentioned above. The third pillar has to do with the legitimacy and democracy aspects of socio-technical and innovation systems and the process of governing their change. This is a fundamental aspect of governance as a collective social process. Our definition of governance of change underlined the notion of actors' interaction and coordination to regulate issues of societal concern. We see actors as the object and subject of this collective coordination. For that reason we are fully aware of the importance of popular support and scientific controversies that can surround processes of governing socio-technical change, and that in democratic societies the input forms of legitimacy through representation and participation channels are as important as the output forms of legitimacy in effective solutions to real collective problems.

Our analytical point of departure is twofold: Firstly, we believe that these three pillars can provide a clear set of separated analytical tools that allow for opening the 'black box' to analyse processes of governing change in systems. Seen this way, examining each of the pillars one-by-one can provide a focused study of essential parts that constitute the complex phenomenon of governing change in socio-technical systems. In this sense, each

of the pillars allows to ask questions about the nature and dynamics of change and governance of change, i.e. about the 'who', the 'how' and the 'why' of governance of change. Secondly, we are also aware, however, that an exercise aiming at conceptual framework-building must be able to generate an analytical framework that links these three together. In this sense, each of the pillars accounts for a limited number of theoretical axioms that work as explicit assumptions about the social action related to the governance of change in complex socio-technical systems. Here we would like to revert to our initial notion of socio-technical systems as being intrinsically unstable, and to our understanding that the 'governance' of change is the way in which societal and state actors intentionally and deliberatively interact in order to transform socio-technical systems. Intention and deliberation are crucial notions here. As will be discussed in detail in the coming sections of this chapter, we assume generally that the ways in which the change in socio-technical systems is governed varies according to the extent to which capable agents are distributed in the system, the way in which the new knowledge and technologies offer new opportunity structures, the way in which public, private and mixed forms of instrumentation re-define incentives, and last but not least, the extent to which the change and its governance is legitimate (Figure 2.1).

Figure 2.1: Three pillars to understand governance of change in STI systems

Figure 2.1
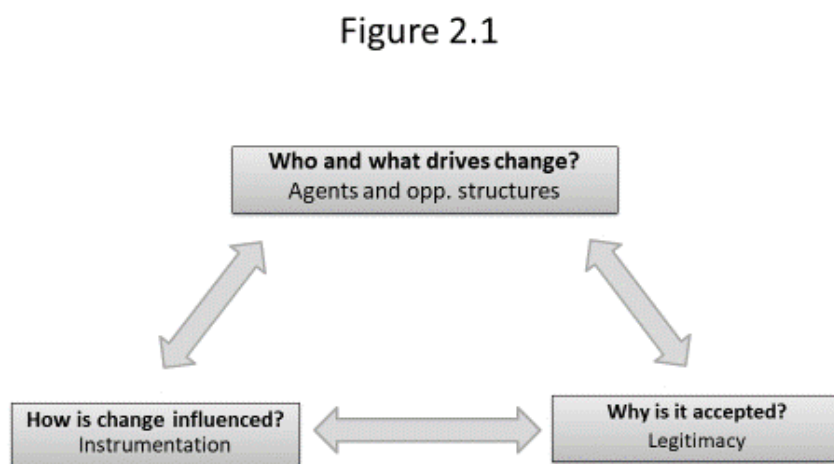
The following sections examine one by one each of these aspects, followed by a succinct summary of the main building blocks and their connection in a concluding section.

2.2 Opportunity structures and capable agents

The first pillar focuses on a lead question regarding the governance of change in socio-technical systems, namely, who and what drives change? The 'who' and the 'what' are fundamental elements in processes of governing change. Therefore, we define and conceptualize the interaction between opportunity structures and capable agents as a key dimension in those processes. To put it up front, opportunity structures refer to the co-evolution of technology and social institutions, which sequentially or simultaneously generate opportunities for change that agents might take. It is important to underline that we do not see opportunity structures generating change per se. The role of agents is crucial in this regard, in particular agents capable of triggering, directing and inhibiting change in the system by co-creating and/or making the most of the new opportunities.

Looking first at opportunity structures, we must emphasise that we see the interaction between and co-evolution of social institutions and their co-evolving with technology at the heart of the process of the governance of change (Casper and Whitley, 2004). Broadly speaking, this follows the axioms of theories of institutionalism, which underline the role of institutions in the shaping of social order and in its process of the governance of change. This is the social order that forms the core of socio-technical systems. In line with the emphasis of STS scholars during the past decades, we see the production and the use of technology and new (scientific) knowledge as being deeply embedded in social organization. Sociological, historical and anthropological studies have shown that the production and use of new knowledge/technology does not take place in a vacuum, but always in a particular social context defined by social institutions (such as regulation and legislation, normative rules, cognitive frames, worldviews, routines, etc.).

From the above it follows that what we define as opportunity structures is not just technology/new knowledge as such, but the structures that result from the embededness of a particular new technology/ knowledge into a set of specific social institutions. It is worth noting that new technology/ knowledge can be seen in two interrelated perspectives. The first one is to see knowledge as the outcome of a social process. New knowledge is never produced in a mechanistic way, but actively involves socio-cultural and individual dynamics in the process of search and exploration of the unknown. For

this reason, the production of knowledge is highly dependent on contextual as well as individual processes. Often these processes are based on human curiosity, the will to unveil the unknown and/or to invent novel technical devices. From sociology of science we know that the Mertonian ideals of disinterestedness and commonality of knowledge production (Merton, 1942/1973) are often met with the reality of individual aspirations for rewards (professional recognition and/or monetary gains) and of the growing commodification of knowledge production processes and outcomes (Callon, 1994). There is a socio-cultural dimension in the production of knowledge, in which scientists and technicians are embedded. The second, interrelated, perspective on new technology/ knowledge is its ability to open new possibilities for social and human interaction and social organization. This is a perspective focusing on the 'content' of the new technology/knowledge, which characterizes the particular nature of this new knowledge and its potential in relation to possibilities for solving problems or granting new venues for social interaction (Nilsson and Persson, 2012). Economists have tended to distinguish between several types of technology 'content' and the innovation processes associated to them. One such distinction is between enabling/generic technologies, with a horizontal effect over several possible socio-technical systems (including different social organizations and/or industrial sectors), in contrast to some more specific types of technologies with a concrete effect on a more limited set of areas or sectors (Niosi and Reid, 2007). Another such distinction is between network technologies (with different levels of entry barriers and network effects) and non-network technologies (David, 1995). The notion of opportunity structures, with its emphasis on the co-evolution of social institutions and technology/new knowledge production and use, and with its focus on the features that characterize technologies (enabling/specific, networked/non-networked, etc.), sheds light on which specific forms of technology production and use might offer new opportunities and openings for new types of social organization. Hence, we need to understand that technologies have specific features which are deeply ingrained in (new forms of) social organization. It is worth noting that 'opportunity structures' are not necessarily 'good' in normative terms. In other words, 'opportunity' might be normatively/ethically problematic and/or socially contested. As we will see below, this matter has to do with the question of societal legitimacy in the governance of socio-technical change, to be explored in the third pillar of our conceptual framework. Hence, 'opportunity' refers here to the new openings and new venues that this interplay between social institutions and new forms of knowledge might offer to socio-technical systems.

As mentioned above, opportunity structures do not generate governance of change per se. The role of agency is crucial in this regard. Two strands of the literature have addressed the issue of agency in the governance of change. The literature on transitions (towards sustainability) has devoted some attention to the governance of change (or what this literature defines as transition management): 'Governance is therefore carried out through negotiation and bargaining between interested state and non-state actors with interdependent resources relevant to the maintenance and change in the regime' (Smith et al., 2005, p. 1498). This negotiation and bargaining is, however, downplayed when the authors look at governance as the exercise of relational power among interdependent agents of change in the process of generating guiding visions, framing problems and motivating other actors towards change, in what seems to be a more discursive/deliberative approach to the governance of change. Elaborating further on the power aspect of agency in the governance of change, these authors have introduced a very relevant distinction between the 'elite visionary agency' and the 'everyday users' agency' (Smith and Stirling, 2010). The former seems, however, to be more determinant in the process of governing change than the latter because visionary frontrunners enjoy more political authority as they can introduce greater changes than everyday users. This authority is also associated to these powerful agents' capacity to position themselves more favourably in the course of events. Following from this, we see the governance of change being generated by intentional and capable agents who are strategically positioning themselves in complex set-ups, who are bargaining and negotiating, but who are also framing problems and solutions. In so doing, they are largely interdependent with each other and interdependent with the 'everyday users' in the system. By and large, these visionary powerful agents have also been related to 'policy entrepreneurs', who develop new ideas, build coalitions, recognize and exploit windows of opportunity, and orchestrate policy networks (Huitema and Meijerink, 2010; Huang and Murray, 2010).

A second strand of literature dealing with agency and change is comparative political economy. Those scholars have not been particularly focused on socio-technical systems per se, but have provided valuable insights in processes of socio-economic change and their governance. Recently, this literature has also been introducing agency-based approaches to change and its governance. This has been prompted by views in the institutionalist and organizational literatures alike, that change is linked to the ambiguity of both, the institutional framework of action and the experience of the agents as such. For Mahoney and Thelen change "often occurs precisely when problems of rule

interpretation and enforcement open up space for actors to implement existing rules in new ways" (Mahoney and Thelen, 2010, p. 4). Hence, they interpret change as being largely dependent on the different degrees of discretion (ambiguity) of those rules, as agents exploit the situation offered by this ambiguity according to their veto power position in the political context. This rational behaviour contrasts however with James March's view on ambiguity. Here, the ambiguity is not of the scope of rule enforcement, but of the experience of agency itself (March, 2010). This author suggests that the past and present experience of agents does not provide them with single-minded unilateral lessons, but with multiple possible lessons because that experience is intrinsically ambiguous and can be interpreted in many possible ways. This means that agents are constantly facing issues about how to interpret their own experience. Any of their positioning or change-attitude is highly related to the way in which they have decided to interpret their experience in the interaction with the social reality. From the perspective of the governance of change in socio-technical systems, these two views are relevant in so far as they recognize that institutions and agent's experiences are ambiguous. However, their very different understanding of social action (utility maximizing vis-à-vis interpretation) results in different views regarding the governance of change. For one school, governance is the dominance of a particular type of utility maximizing agents, whereas for the other, it is the pre-dominance of specific interpretative frameworks. With this, we find ourselves in the classical conundrum of whether social action has one or multiple natures (rationalist or interpretative, or both at once).

Both strands of the literature bring relevant insights to our conceptual framework. Transition scholars bring forward the idea of different types of agency in the governance of change in socio-technical systems; and the comparative political economy literature brings forward the view that ambiguity is an intrinsic element in the agent's perceptions as well as in the way in which social institutions (regulation and legislation, normative rules, cognitive frames, worldviews, routines, etc.) are differently organized and interpreted by the agents.

Yet, acknowledging these contributions does not solve our theoretical problem regarding the nature of social action, nor the nature of agency-institution relations in the dynamics of governing change. We need to be more precise. Our first point of departure is the understanding that in societal and political contexts such as the governance of change in socio-technical systems, agents might chose to operate either under the logic of consequentiality, whereby action is driven by actor's preferences and interest and thus

expected outcomes, or under the logic of appropriateness, whereby action is driven by the perception of what is necessary and conforms to a given set of norms and rules (March and Olsen, 1989). Both logics can – in fact will – co-exist in time. Our second point of departure is the understanding that the agents of change can be everyday agents (civil society organizations, lead consumers, non-governmental organizations, social entrepreneurs, community managers, etc.) as well as more formalized agents (policy entrepreneurs, firms, researchers, inventors, etc.). These agents might have different capabilities in terms of their resources; and these resources might be evenly or unevenly distributed.

An example at hand is the governance of change in the commercial aviation transport system in Europe in the 2000s, with the introduction of an entirely new business model - discount flight companies. This was based on a combination of opportunity structures and capable agents governing change in this specific socio-technical system. First, the co-evolution of a set of socio-political institutions (EU regulations liberalizing the air transport sector aiming to create a single market in Europe) and the advancement of ICT on-line solutions (technology) provided an opportunity structure as an opening. Second, capable agents (newly capitalized aviation companies during the expansive capital markets at the end of the 1990s) made the most of the opportunity by designing a new business model based on cheaper retailing prices, and self-service on-line booking by passengers.

The first pillar of our conceptual framework, opportunity structures and capable agents, looks at the ways in which the different nature of opportunity structures (combinations of new technologies and knowledge with institutional frameworks) and different capabilities of actors offer different contexts for the governance of change. Systems in which network-based technologies are dominant will have specific forms of opportunity structures compared to those in which the dominant technologies are more self-contained. In addition, we stress the importance of the interaction with social institutions. Social institutions like regulation, normative rules, worldviews, routines, etc. interact strongly with these technologies/new knowledge, co-evolving in mutual interdependence. Social institutions might enable or constrain the production and use of technologies and hence shape and co-evolve with these technologies. Hence the main question related to opportunity structure is: What are the ways in which new technologies and knowledge, and their interplay and co-evolutions with social institutions offer different contexts for the governance of change in socio-technical systems?

Our conceptual framework is eminently agency-based. As mentioned above, ambiguity is a constitutive element in agents' experience as well as social institutions. The creation of new knowledge and technology might tend to increase the levels of ambiguity, and therefore to transform the space for individual/collective action as well as for the (re-)interpretation/re-organization of social institutions. Resources not only in terms of monetary/economic resources, but in terms of other resources like expertise, time, influence, social legitimacy, etc. are also related to the agents' interpretative abilities (as communicative and coordinating devices promoting or hindering change). Resources and interpretative abilities are crucial features defining the level of capability of the agents. For this reason, the distribution of these capabilities in the system is an issue worth studying in the processes of governing change. In sum, the questions related to agency are: Who are the primary agents of change? What is their capacity to induce/inhibit change? What capabilities do they have (resources and interpretative abilities)? And, what is the distribution of the agents' capabilities within the system?

2.3 Instruments in the governance of change

The second pillar is concerned with the *how*, namely with the instruments used in the governance of change, i.e. the specific ways and mechanism in which agents induce change in the socio-technical system and are able to design and give direction to that change. Before taking a step further into this discussion, it is paramount to underline that 'governance instruments' is a generic concept referring to different possible types of instrumentation in the process of inducing change. Hence, 'governance instruments' is an umbrella concept that includes the notions 'policy instruments' when those designing those instruments are primarily state agents; and it includes as well 'social agent's instruments' designed by non-state agents. For this reason, the notion 'governance instrument' is an umbrella notion focusing on a broad range of mechanisms for social action (Lascoumes and Le Gales, 2007) conducive to governing change in socio-technical systems.

There is a wide scholarly literature on instruments which differs based on the relative importance of either state or societal instrumentation. The different disciplines in the social sciences have their own views on the nature of social action, and also on the expected roles of state and social agents. This means that, traditionally, different social sciences' disciplines have tended to look at specific bundles of governance instruments

while disregarding others. Therefore, it is important to take stock of these different paradigmatic views in order to broaden the debate and provide an encompassing and holistic view on governance instrumentation, connecting the traditional public policy with societally-driven instruments.

On the traditional policy analysis end of the spectrum, the literature tends to see state policy as the most prominent actor in the governance of change, because the state has the main (but not sole) responsibility for 'policy' instruments for governing change in socio-technical systems. Economists share this view in part, particularly on the state as an actor in different modes of hierarchical coordination. In this state-focused view, economists and political scientists have analysed and justified policy instrumentation on the basis of three basic rationales for state intervention: (1) correcting market failure, (2) correcting systems failure and (3) achieve certain missions/goals. The first, market failure, is the most traditional policy rationale for science and technology policy and has mainly been concerned with the need to support public and private investment in science and research in order to address problems of sub-optimal investment ratios due to the limited private incentives and long-term returns (vs. short term returns) of those investments (Arrow, 1959/2002; Nelson, 1959). Correcting system failure is the second rationale of policy instruments. Policy instruments induce change in the system by addressing specific problems, deficiencies, or bottlenecks (Borrás and Edquist, 2013; Smits and Kuhlmann, 2004; Edler and Georghiou, 2007) on the supply side, the demand side, and as regards the interplay of the two. The third rationale for policy instruments has to do with supporting the achievement of specific goals or missions, a rationale becoming increasingly important as illustrated, inter alia, by the move towards public policies instruments to address grand social challenges (Omenn, 2006).

Sociologists have been less concerned with traditional ST&I *policy* instruments, but tended to focus on social agent's instruments. They have stressed different mechanisms, modes, or 'strategies' of governance within heterarchic governance structures that co-evolve around certain techno-scientific areas and/or around specific concerns or opportunities associated with them. The notion of emergent governance (Kearnes and Rip, 2009) and anticipatory governance (Roco, 2006, Barben et al., 2008) highlights the fluid character of instruments that aim at governing change which has to do with uncertainties in socio-technical systems. Likewise, the notions of adaptive governance (Smith and Stirling, 2008) and distributed governance (Abbott, 2000) highlight the heterarchical, poly-centric nature of instruments, which are essentially social agents'

instruments. Instrumentation in this sociological approach is different from the state-led 'policy instruments' mentioned above, because the former comprises social agents' interactions. The bulk of the discussion on governance instruments in the STS tradition has revolved around the ways in which social agents shape and change. One set of social agents' instruments is discursive and relies on stakeholder participation (Joss, 1999; Korthals, 2011; Davenport et al., 2003). Other instruments support the discourse on longer term developments and alternative futures (foresight, Miles, 2010) or around specific technological trajectories and their opportunities and risks (e.g. technology assessment). The most comprehensive form of technology assessment, constructive technology assessment (Rip, Misa et al. 1995) (Schot and Rip, 1998) (Schot, 1991), mobilizes input and feedback on technologies in early design stages and for re-design of technologies from all interested parties (end user, technical experts), thus not only assessing technologies, but influencing and governing the process of change in the socio-technical system. Another set of social agents' instruments are non-binding, voluntary arrangements such as voluntary reporting schemes or stewardship programmes[1], voluntary self-commitments codified in professional ethics and technology specific codes of conduct (e.g. Bowman and Hodge, 2009; Webb, 2004; Koutalakis et al., 2010). Those instruments "harness market, peer and community energies to influence behaviour, and draw on the infrastructure of intermediaries such as industry associations, standards organizations and non-governmental organizations for rule development and implementation" (Webb, 2004, p. 4).[2] They codify norms and establish a soft form of accountability.

From the above it can be seen that the literature has looked at the issue of instruments, either by focusing on state-led policy instruments or by focusing on societal-led social agents' instruments. Some scholars, however, have aimed at integrating both the view on state and social agents. The transition *management* literature (Kemp and Rotmans, 2004; Kemp and Loorbach, 2006; Loorbach, 2010) has captured the various roles the state plays in systemic governance of change (Kemp et al., 2006, p. 394), by partly integrating it with social agents' instruments.

In this chapter our view is that we need a broader perspective on governance instruments (an umbrella concept that covers the state-led policy instruments and the socially-led social agents' instruments) for understanding the governance of change in socio-technical systems. This broader perspective of the instruments for the governance of change is needed for three reasons: First, it is an empirical question to what degree the state-led

policy instruments in the governance of change in socio-technical systems are effective in influencing the *direction of* change and the *motivation and ability* of agents to change a socio-technical system. Second, the design and implementation of most of the governance instruments (both policy instruments and social agents' instruments) is important for explaining the process of governing change. And third, it is worth noting that traditional policy instruments have increasingly been underpinned and accompanied by social agents' instruments, whereby state and social actors design different but complementary instruments that interact to govern change in the system. In other words, different instruments are combined in specific mixes, some of which might collectively induce change, while others might not.

To sum up, the study of instruments needs to bring forward questions related to who is designing, shaping and using the instruments; how the instruments are shaped in the first place and by whom, and how those instruments are put into practice and implemented. The co-existence of the state-led policy instruments and social agents' instruments lends itself to see how these types of instruments interact, and how potential tensions are resolved, or the instruments' different goals coordinated. These remarks suggest that it is worth going beyond studying the effectiveness of instruments in the traditional evaluative sense (impact assessment) and to study as well the instruments' broader benefits. Here the notion of 'public value', recently put forward by authors in the field, might be a good starting point to grasp that broader view (Bozeman and Sarewitz, 2011). Likewise, one must avoid a 'linear' understanding of governance instrumentation, as if instruments were invariably having a direct and unidirectional effect on the governance of change in socio-technical systems. In this sense, it is important to understand the complex and reflexive design and use of instruments, for example, the ways in which societal actors shape and re-shape the orientation, sense-making and cognitive frames in the reflexive process of designing and using instruments in the governance of change. This is particularly visible in the context of social contestation and scientific controversies, when the non-neutrality of the policy and social agents' instruments become more exposed. With this in mind, we turn now to the issue of legitimacy.

2.4 Legitimacy of the governance of change in socio-technical systems

The third pillar has to do with the question why socio-technical systems are (or are not) accepted, and why the process of governing change is (or is not) accepted. In our view,

the concept of legitimacy must be at the heart of discussions about the governance of change in socio-technical systems, both in terms of its normative content and an in terms of an analytical framework for an analysis of the nature and scope of the social acceptance of the change in socio-technical systems. To be sure, socio-technical systems are legitimate if they enjoy wide social acceptance and support. The process of governing change must also be legitimate.

The reasons for the need to focus on legitimacy are threefold. The first reason has to do with the uncertainty of the challenges inherent in any change or transition because of the 'unfamiliarity among stakeholders with the new activity and disputed conformity to existing institutional rules' (te Kulve, 2010, p. 18). The uncertainty and related contestation of scientific and technological change necessarily asks for grounding of legitimacy for decisions taken that shape that change. The second reason is the inherent political nature of all change, since shaping the direction of science, technology and innovation inevitably effects the interests (and material benefits) and value systems (ethical, normative preferences) of all stakeholders, no matter if they are actively involved in the governance process or not. The third reason has to do with the claim of new governance approaches to lead to binding decisions and socially shared direction. It is derived from the notion that, socially shared legitimacy beliefs serve to create a sense of normative obligation that helps ensure voluntary compliance with undesired rules or decisions of governing authority, (Scharpf, 2009, p. 5). While Scharpf refers initially to the more traditional role of the state and its authority, his remarks are also applicable to the broader concept of governance, as a voluntary compliance with the outcome of collective decisions and coordination processes is at the very heart of governance approaches.

The various literature strands on change of socio-technical systems and their implicit views on the governance of that change share a – largely implicit – normative consensus about the need for legitimacy, but there is not much of an explicit conceptualization of legitimacy as such (Borrás, 2006b; Sylvester, Abbott et al., 2009). Rather we find many claims about the lack of legitimacy, about the problems to achieve it, or about the ways to create more of it. However, the concept of legitimacy itself is rarely defined explicitly in terms of concrete analytical and normative dimensions, resulting in a lack of proper operationalization of the research design on questions related to the societal acceptance and democracy in the governance of change in socio-technical systems.

One starting point for conceptualising legitimacy is the general notion of David Easton whereby systems are legitimate if they enjoy popular support, both in terms of the process by which the decisions were taken (input legitimacy) and in terms of the support of the system's outcomes (output legitimacy) (Easton, 1965). Input legitimacy refers to the popular support that a particular social community grants a political system (a specific set of political institutions) to channel collective problem-solving for that community. Several decades of political science studies have distinguished between different ways of 'channelling'. Normative theories of liberal democracy see input legitimacy essentially as an issue of traditional forms of political representation through free political party contestation, elected into a democratic Parliament with real legislative powers (Cunningham, 2002). The social community is represented in a political body with specific powers to make decisions about how to solve collective problems. Those decisions are socially accepted and democratically legitimate in so far as they entail forms of negotiation that represent the different interests within the community. For their part, normative theories of deliberative and participatory democracy see input legitimacy as a form of direct participation of the community (citizens, civil society organizations, etc.) into formal and informal processes of decision-making, that are not based on political negotiations or direct contestation, but essentially on deliberation and consensus-building processes (Bohman and Rehg, 1997). The decisions are socially accepted and democratically legitimate in so far as the process to reach them has been inclusive, open to deliberative considerations and directly engaging those affected by the decisions. Naturally, these normative theories of democracy view input legitimacy differently. However, it is important to understand that both give considerable attention to the process of decision-making. In other words, democratic theories tend to be procedural in nature, looking at the mechanisms of representation/participation in the input-side of the legitimacy of a system.

Output legitimacy is the 'success' that governance delivers, the effectiveness to solve problems and to achieve what is perceived as being in line with main societal preferences. In other words, output legitimacy is the popular support given to a system due to its real capacity to solve collective problems. By the same token, the lack of problem-solving capacity potentially de-legitimises processes and the system as such (Scharpf, 1999).

When looking at the input legitimacy aspects, the STS literature is very rich and suggestive in its focus on the roles of citizens and experts and their participation, engagement and consensus-making in socio-technical systems, or the lack thereof. The

burgeoning literature on science and democracy takes into consideration the different models of democracy mentioned above, as alternative institutions of voice (Ron, 2011), or through more elaborated and hybrid forms of representation and participation (Fischer, 2011). Deeply entrenched in these discussions are issues related to preferences towards the empowerment of citizens or the empowerment of scientific experts as the best mechanisms to secure a legitimate scientific-related decision-making (Borrás, 2012) for a review. Among the former, we find arguments that fostering the public understanding of science among citizens (Miller, 2001) will allow for an informed public debate on crucial science–technology decisions; and that constituting 'science citizens' will engage them in participatory mechanisms that generate deliberation (Hagendijk and Irwin, 2006; Liberatore and Funtowicz, 2003). Those advocating the empowerment of experts instead see the delegation of decision-making to non-majoritarian independent regulatory agencies based on 'sound academic science' as an important mechanism of legitimacy (Majone, 2010). Another perspective on empowering experts argues that widening the scope of who is an expert, including conventional academic science but also knowledgeable experts from civil society, will generate 'socially robust knowledge' that legitimates decision-making (Nowotny, 2003). However, even if directly related to legitimacy, much of this rich literature does not refer explicitly to the notion of legitimacy, and therefore has so far not been able to connect to the political science discipline dedicated to these matters. There is therefore a gap between the view on legitimacy from normative theories of democracy, on the one hand, and the discussions about citizens' and experts' democratic role in socio-technical systems, on the other.

Something similar can be observed with respect to output legitimacy. By and large, the traditional literature on policy analysis and economics in socio-technical systems has so far been concerned with questions of effectiveness and efficiency, with what is being delivered. The scholars studying the effectiveness of science, technology and innovation (STI) policies and evaluating the performance of particular socio-technical systems have never discussed issues of performance and effectiveness in terms of legitimacy. Therefore this literature has does not have too much to offer in terms of the legitimacy debate around socio-technical systems. In any case, one important remark in this literature has been recently put forward by Smith and Sterling (2008). They see a dilemma between promoting (effective) transitions in socio-technical systems on the one hand, and the democratic aspects of (input legitimacy) in the political representation/participation in decision-making, on the other:

[i]t is unclear how these [transition management processes] sit in relation to prevailing policy institutions and political activities. Transition management is not unique in this regard, as other participatory approaches share this dilemma. However, given ambitions to transform the structures of our everyday lives, this unclear relationship is especially problematic because the basis for authority, legitimacy and accountability in transition governance will ultimately rest on the way it engages. (Smith and Stirling, 2008, p. 11)

Seen from the input-output legitimacy perspective mentioned above, this seems to be a redundant dilemma because input and output legitimacy are two sides of the same coin. There are two reasons for that. Firstly, as Mayntz suggests, in heterogeneous societies the '…very difficulty of defining what constitutes a legitimating output thus emphasizes the importance of input legitimacy' (Mayntz, 2010, p. 11). The point is that, even if outputs are supported by majorities, the ability of the minority to accept that output still rests on the perception that the processes that defined the outcome was participative, open and transparent. Secondly, the complex nature of socio-technical systems makes the participatory and effective governance of change in socio-technical systems more dependent on the knowledge of citizens and experts alike, precisely because the nature of 'effective outputs' might be contested. This means that the most effective solutions are often those that have been based on a participatory/representative process of decision-making. This however might be challenged in contexts of high scientific controversies or contexts with high levels of uncertainty.

The analysis of the governance of change in socio-technical systems is confronted with a challenge it has yet to master, and thus we see that more appropriate approaches to study the legitimacy in the governance of change in socio-technical systems are needed. Hence, our first point of departure is that there is a need to bring forward more analytical and empirical efforts when studying the legitimacy of socio-technical governance in general and of governance of change in socio-technical systems in particular. Questions of legitimacy are intrinsically normative, because they are ultimately based on normative theories of democracy and social order. However, the pleas towards more analytical endeavours on issues of legitimacy (Wessels, 2003) can also be applied to this particular topic. We can illustrate the directions in which this should go with three examples. The first example is the recent effort to test the argument that more participation of stakeholders has generated more input legitimacy. This was studied in the case of a

specific new policy instrument in the EU used in STI policy-making (Borrás and Ejrnæs, 2011). A second example for this more empirical endeavour is to focus on certain elements of the governance systems (regulatory bodies) and to analyse their embeddedness in different 'legitimacy communities'. This enables the scholar to develop an analytical concept to actually understand the link (or lack thereof) between strategic behaviour and input/output legitimacy (Black, 2008). In a similar vein, other authors have analysed the input legitimacy of regulatory agencies by looking comparatively at the different levels of stakeholders networks' involvement in decision-making processes (Borrás et al., 2007) and the input-output legitimacy of complex regulatory systems like the patent system (Borrás, 2006a). Last but not least, another example of analytical efforts has been put forward by Geels and Verhees (2011). These authors study 'cultural legitimacy' as a combination of cognitive and normative dimensions of legitimacy. This allows them to study longitudinally the 'framing struggles' for cultural legitimacy in a specific socio-technical system (nuclear energy).

Our second point of departure is that the ways in which socio-technical systems are governed have become much more diffused, with hybrid and heterogeneous arrangements, and are evolving rapidly. For that reason, the aspects of legitimacy need a much more careful consideration because, following Scharpf, the perception of legitimacy is related to the readiness of societies to contribute to the process and to comply with directions taken. With the emergence of complex governance forms, the rules of the game and the mechanisms of inclusion / exclusion in participating are becoming less clearly defined. Hence, questions regarding the sources of legitimacy need to be asked more consistently and sharply: How are the conventional mechanisms of parliamentarian representation and non-parliamentarian forms of deliberation balanced and managed? If there is participation in deliberation around specific technologies, how are access and exchange organized, and how are results of deliberations channelled? (Davenport et al., 2003)?

All in all, the above discussion has shown that a conceptual framework to understand governance of change in STS systems needs to put questions of legitimacy at its core. This leads us to the formulation of a set of building blocks and then allows the formulation of lead questions. First of all, input and output dimensions of legitimacy cannot be disconnected from each other in the process of governing change in a system, as both are needed to grant legitimacy to the process of governing change. If one is absent, the process of governing change will be compromised in terms of legitimacy. Secondly,

governance of socio-technical systems and their change is legitimate when it is characterized by a normatively appropriate process (defined by the different theories of democratic legitimacy mentioned above – liberal-representative, participatory and deliberative) and by socially endorsed processes (defined by levels of social support) through mechanisms of participation and representation. This is linked to social views and expectations about the outcomes of the change in the socio-technical systems that are widely shared cognitively and normatively (Scott, 1995) in open and explicit reflexive processes in society.

This allows the formulation of concrete analytical questions: What are the challenges for legitimacy emerging from the combination of specific actor arenas and the poly-centrality of governance? What is the cultural embedding of governance instruments that are applied and how does it change over time? How socially accepted are the governance processes and outcomes, and why is this? How is contestation of outcomes and processes dealt with? All of these questions have an analytical and a normative dimension. On that basis, empirical analysis could feed back more explicitly into normative theoretical issues, providing more fine-grained and empirically-grounded normative understandings of the general standards regarding input and output legitimacy of socio-technical governance and its change in contemporary societies. It goes without saying that an analysis of legitimacy as suggested here needs the multidimensional perspective that is at the heart of the rationale for our conceptual framework in the first place.

2.5 Conclusions

The overall goal of this chapter has been to address the issue of the governance of change in socio-technical systems. Taking the vast literature in the field of socio-technical and innovation systems as our point of departure, (see Introduction to this volume), we have aimed at conceptualizing governance of change in socio-technical systems. This conceptualization heavily draws on the political science background on these matters. By drawing from the political science disciplinary insights, this chapter has provided a first attempt to bridge the gap between different approaches through conceptual development, through bringing those literatures together and through identifying concrete empirical questions ahead. In so doing, we have dared to take a careful step forward in our effort to provide a consistent analytical framework. We call this preliminary conceptual framework-building. We believe that our three pillars offer a clearer structuration of the
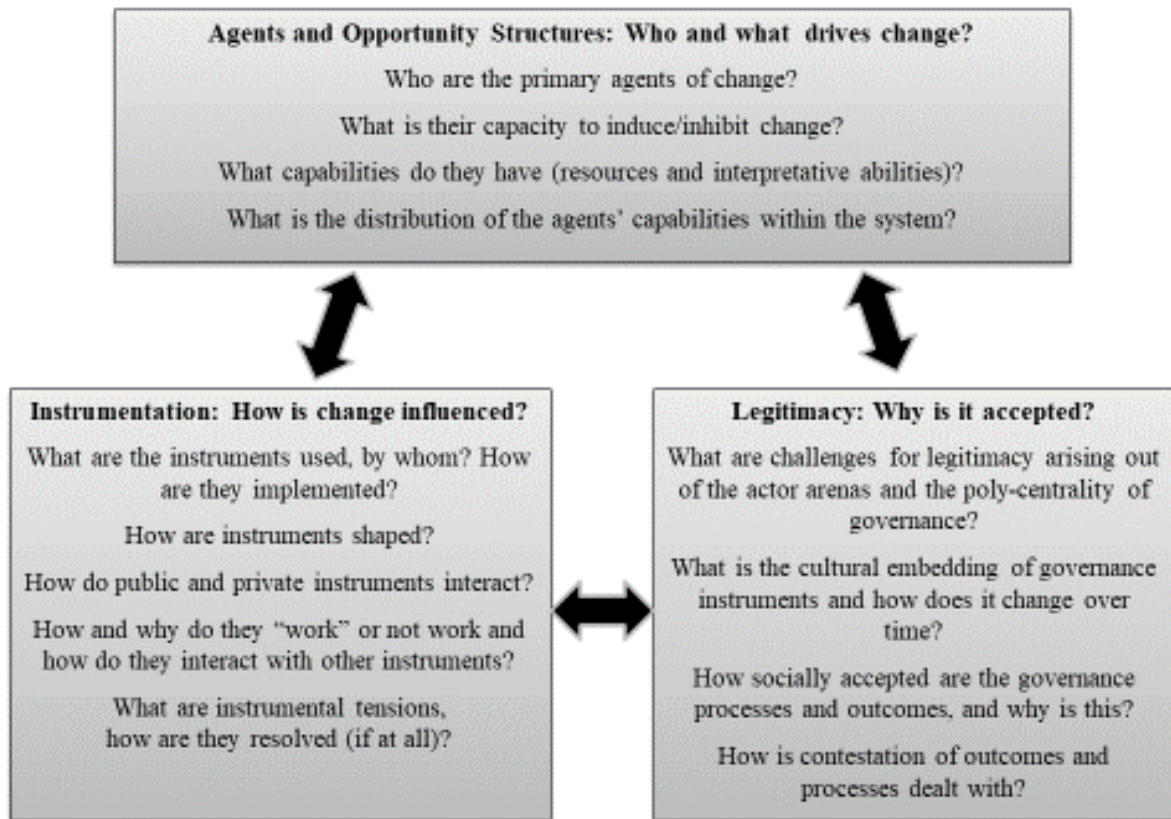
central dimensions related to the governance of complex socio-technical systems, and that this offers a novel angle on these matters because it brings key issues from political science into this multi-disciplinary scholarly community that otherwise has not been in contact with the governance disciplinary discussions. Our true ambition has been to structure those lines of inquiry into a coherent whole, to identify analytically relevant issues and to pose questions that were partly disregarded and need further empirical work. Having said that however, we can summarize our main assumptions from this first step into the endeavour of theorising the governance of change in socio-technical systems:

- Change in socio-technical systems is driven by the interplay between the opportunity structures (defined by the co-evolution of new technology and knowledge with institutional framework conditions) and the actions and reactions of different agents of change.

- The **governance** of change in a socio-technical system is essentially the governance of institutional frameworks (which define the opportunity structures for agents) and the subsequent transformation of the agents' behaviour.

- The agents of change can both be elites (i.e. policy entrepreneurs, specifically large firms) or everyday agents, depending on their respective capacities and on the top-down or bottom-up social dynamics in the socio-technical system.

- As change inserts uncertainty, the compliance discretion of institutions and the agents' past experience are intrinsically ambiguous. For that reason, the governance of change is rarely an uncontroversial or smooth process. Battles over the specific interpretations of institutional frameworks and over societal and stakeholder costs-benefits characterize the process of socio-technical change and its governance.

- To understand the 'how' of governance of change, it is important to develop a broad perspective on instruments (beyond the traditional 'command and control'), including public, private and joint instrumentation.

- The policy analysis tradition (interested in the effectiveness of policy instruments in a more traditional, evaluative sense) is not sufficient to understand the governance of change. Therefore we include a broader understanding of the dynamics and processes of governance. By doing so, we can better grasp how instruments are shaped in the first place, better explain why they do or do not 'work', and how they interact with societally driven governance mechanisms.

- Various forms of governance instruments include the state-led policy instruments (designed and implemented by public authorities) and the socially-lead instruments (designed and used by societal actors). The governance of change in socio-technical systems is usually characterized by specific mixes of different instruments, sometimes working in the same direction of change, sometimes not. We need to better understand how these specific combinations of instruments induce change (or not).

- The ways in which socio-technical systems are governed have become much more diffused (with hybrid and heterogeneous institutional arrangements and multiple instruments) and have become more rapidly evolving. Those complex and rapid changes are more subject to societal contestation than before. For these reasons, the aspects of legitimacy are at the core of our understanding of change and its governance.

- Our framework brings forward the argument that we need more analytical and empirical efforts in the study of the legitimacy of socio-technical governance in general and of governance of change in socio-technical systems in particular. We differentiate input and output dimensions of legitimacy, which cannot be disconnected from each other, as both are needed to grant legitimacy to a socio-technical system. Input legitimacy (which is more procedural) is intrinsically linked to the perceptions of effectiveness of change (the output legitimacy). The governance of change in socio-technical systems is intrinsically related to developing a process that underpins input legitimacy as well as output legitimacy.

Against this background of core assumptions and principles, we can formulate a set of basic analytical questions to understand specific situations of governance change. Figure 2.2 below summarizes the concrete questions that need to be answered for the three core pillars of our framework. This is at the same time a – simplified – guide to the understanding of the empirical examples in the following chapters of this book.

Figure 2.2: Key analytical questions stemming from the conceptual framework

Agents and Opportunity Structures: Who and what drives change?

Who are the primary agents of change?

What is their capacity to induce/inhibit change?

What capabilities do they have (resources and interpretative abilities)?

What is the distribution of the agents' capabilities within the system?

Instrumentation: How is change influenced?

What are the instruments used, by whom? How are they implemented?

How are instruments shaped?

How do public and private instruments interact?

How and why do they "work" or not work and how do they interact with other instruments?

What are instrumental tensions, how are they resolved (if at all)?

Legitimacy: Why is it accepted?

What are challenges for legitimacy arising out of the actor arenas and the poly-centrality of governance?

What is the cultural embedding of governance instruments and how does it change over time?

How socially accepted are the governance processes and outcomes, and why is this?

How is contestation of outcomes and processes dealt with?

Our conceptual framework shall serve as a guide to understand concrete change processes and their governance. However, we see this as a first step in the development of a mid-range theory of the governance of change. To work towards such a theory, a set of further steps will be needed.

Concrete studies of the governance of change in socio-technical systems might help us to better understand the interdependence of the three pillars. The empirical findings will provide solid grounds to identify patterns of recurrence in the interrelations of these pillars. For example, do we see a specific relationship between certain characteristics of new knowledge and new technologies (such as the level of uncertainty and disruption, or the network-nature of technology in question) and certain patterns of agency of change (policy entrepreneurs, or large firms' agents of change)? Can we see as well linkages between the types of agents of change (elite or everyday agents) in relation to the forms of input legitimacy of the governance of change process? Or can our empirical studies identify a link between certain features of the opportunity structures (defined by the new

technology and the institutional set up), with specific mixes of social and policy instrumentation? Likewise, can we identify a link between specific instrumentation mixes and with particular forms of output legitimacy (effective solutions and their widespread acceptance in the society)?

Having a substantial amount of empirical material from which to identify patterns of interactions and co-existence, our theoretical framework would need to take a further step looking into the overall process of learning and reflexivity in the governance of change processes. Our advanced societies are constantly engaged in processes of governing change in socio-technical systems. With the three pillars we have identified some building blocks for a better understanding of the governance of that change. However, we would also need to study the conditions under which this governance of change is characterized by learning processes and if there are some patterns of collective self-reflexion of these governance processes. This would also include the need to understand situations in which learning and reflexion does not take place, resulting in repeated situations of 'lock in' in the different processes of governing change. It is our understanding at this preliminary stage that low levels of learning and reflexivity reduce the collective and individual capacity of agents of change to induce and govern change. The nature and extent of learning from past experiences in the (perceived as successful/unsuccessful) governance of change might enhance or hinder possibilities of further change.

Last but not least, the future development of a meso-range theoretical framework on the basis of empirical analysis and on considerations at meta-level (reflexivity and learning in governance processes) will provide a sound basis for the definition of a series of recommendations for the design of strategies to govern change in socio-technical systems. Those recommendations would naturally have a normative nature in the sense that they would be a series of theoretically and empirically-informed recommendations about specific courses of action.

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[1] For illustration: DEFRA (2008)

[2] Examples of broader codes in the area of Nano are Examples are the Responsible Nano Code http://www.responsiblenanocode.org/ in the UK or the EU Nano Code http://ec.europa.eu/nanotechnology/pdf/nanocode-rec_pe0894c_en.pdf