Three Tensions in the Governance of Science and Technology

Susana Borrás

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ABSTRACT:

This chapter suggests that the governance of science and technology is characterized by three sets of persistent tensions, namely the tension between the self-organization of S&T and the politics of purpose; the tension between hierarchy, network, or market forms of organizing interactions; and the tension between the role of citizens and that of scientific experts in the decisions about collective problems and their solutions. The main argument of this chapter is that these three tensions have become more intense during the past few decades, and that they reflect the overall move from government to governance. The main point is that during the past few decades there has been considerable multiplication and sophistication of the institutional arrangements that mediate and govern the three tensions mentioned above. Tensions that were once resolved in a rather straightforward and hierarchical way are now subject to many different co-existing and heterogeneous institutional arrangements that define solutions in complex, dynamic, and overlapping ways. The natural question that emerges from this is whether this multiplication and heterogeneity of institutional arrangements is having an impact on the effectiveness and legitimacy of S&T governance. Addressing this question would require a renewed research agenda for the social sciences cutting across strict disciplinary boundaries. The final section of this chapter suggests that such a renewed research agenda would need to focus on bringing forward a 'systems' approach to the study of effective S&T governance, and an empirical approach to the study of legitimate S&T governance.

1.- Introduction

Science and technology are fundamental factors for human and economic development, defining almost every detail of our lives. Pertinent examples of this are the Internet's effect on radically new forms of social communication and business models; nuclear weapons' redefinition of security threats and warfare; and the supply of clean water in households determining basic sanitary and hygienic conditions. Yet, there are many paradoxes in all this. Science and technology continue to be scarce goods for most of the developing world, whereas in the industrialized world there is a hot debate on whether the 'soft' innovations in the service sector will prevail over the 'hard' science and technology in the manufacturing sector as the main sources of economic growth. Furthermore, even if there is a widespread understanding that science and technology are behind the improvements in life quality and human progress, not all aspects of science and technology are consistently accepted by society. Fundamental controversies regarding the causes of global warming or the use of embryonic stem cells for therapeutic purposes continue to unravel.

The remarks above serve to underline a series of fundamental premises of this chapter, some of which are not entirely uncontroversial, namely that science and technology shape and are shaped by specific forms of social, political, and economic organization; that science and technology are far from being uniformly institutionalized, developed, exploited, or even accepted by the society; and that the forms in which science and technology are governed are highly diverse according to the way in which a society organizes itself.

Social scientists have analysed the role of science and technology from different angles, in what seems to be a very rich pool of research endeavours. Scholars in STS (science and technology studies), economics, and political science disciplines have been concerned with the complex micro- and macro-level dimensions of the science–society/economics/politics relations and their mutually shaping interactions. With few happy encounters these research endeavours have run parallel with an unfortunate disregard for each others' contributions. Yet, during the past few years these three traditions have coincided in embracing the notion and perspective of 'governance', in what appears to be a growing but unnamed common ground among them. Economists' interest in issues of governance stems from the evolutionary and institutional economic theory's view that technical change in the economy takes place in compound systems of socio-economic and political institutional arrangements (OECD, 2005) (FORAY and LUNDVALL, 1996). Likewise, the STS scholarship has recently put forward the notion of 'scientific governance' as a way of grasping the changing role of scientific knowledge in different dimensions of social organization (IRWIN, 2008). Political scientists, for their part, being those who initiated the scholarly attention on 'governance', have been looking at multi-level governance (EDLER et al., 2003) (KAISER and PRANGE, 2004), new modes of governance (LYALL and TAIT, 2005), legitimate governance of socio-technical systems (BORRÁS, 2006a), and various forms of policy instrumentation and coordination (BRAUN, 2008) (SMITS and KUHLMANN, 2004).

This chapter suggests that the governance of science and technology is characterized by three sets of persistent tensions, namely the tension between the self-organization of S&T and the politics of purpose; the tension between hierarchy, network, or market forms of organizing interactions; and the tension between the role of citizens and that of scientific experts in the decisions about collective problems and solutions involving science and technology. The main argument of this chapter is that these three tensions have become more intense during the past few decades, and that as a result, there has been an overall move from government to governance. The shift from

government to governance is because there has been considerable multiplication and sophistication of the institutional arrangements that mediate and govern these three intensified tensions. Tensions that were once resolved in a rather straightforward and hierarchical way are now subject to many different co-existing and heterogeneous institutional arrangements that define solutions in complex, dynamic, and even overlapping ways.

The next sections set out to examine one by one each of the three tensions and the way they fit into the general claim of a gradual shift from 'government to governance' (KOOIMAN, 1993) (PIERRE, 2000) (BEVIR, 2011) (RHODES, 2011), by looking carefully at the features of their institutional arrangements and the changes in the patterns of (state) authority in the field of science and technology. The concluding section is devoted to looking further into the argument that there is growing heterogeneity and hybridity of the institutional arrangements (LEVI-FAUR 2012) addressing these increased governance tensions, in view of defining succinctly some crucial aspects for a renewed interdisciplinary research agenda about the effectiveness and legitimacy of S&T governance.

2.- Between Self-Organization and the Politics of Purpose

The organization of science and technology has historically been trapped in a tension between the autonomy of creativity and the politics of purpose: between the scientists' and the technicians' own organizational rules, and the state's interest in using science and technology for purposes of defence, economic growth, public health, and others. This was reflected in the well-known debate in England in the 1940s between Polanyi and Bernal. In his ardent support of scientists' autonomy in the 'Republic of Science' Polanyi stated that 'Any attempt at guiding scientific research towards a purpose other than its own is an attempt to deflect it from the advancement of science' (POLANYI, 1962). In contrast to this, Bernal claimed the essential socio-economic function of science, invariably requiring the grand mobilization of knowledge in order to achieve explicitly formulated goals in planned economies (BERNAL, 1939/1967). Much of these two contesting views has to do with a centuries-long debate about the organization of science, its nature, and its relation with political life (TURNER, 2008), as well as about the role of scientific–technical knowledge and governmental intervention in economic development (FREEMAN, 1995).

This tension persists today. On the one hand, since the advent of the welfare state and the Cold War there has been a continuously growing governmental involvement in science and technology. Massive investments in 'big science' reflect political ambitions of military superiority and security (HUGHES, 2003) (JAMES, 2006). In the 1970s, the political willingness to emulate the 'Asian miracle' triggered substantial efforts to increase the levels of R&D expenditure in strategic industries, as well as policies for the knowledge-based economy in the 1990s (LUNDVALL and BORRÁS, 2005). On the other hand, the substantial up-scaling of scientific and technological endeavours has been based on a tacit 'social contract for science' that regards the autonomy and self-organization of the scientific community as a premise for its ability to deliver reliable results to these purposeful objectives. In a sense, the massive state involvement in the twentieth century created a space for the development of resilient institutions, norms, and values emanating from the scientific community itself (i.e. peer review, use of specific scientific methods, etc.), and for the unfolding and use of science and technology in the society and economy.

During the past few decades, however, the tension between the politics of purpose and the self-organization of S&T has become more intense, as the 'social contract' described above has been under pressure from several interrelated fronts. The first front has to do with the changing societal expectations about the role of science in society. The traditional 'social contract of science' is based on an unveiled positive view of science as an 'ivory tower', in the expectation that science produces reliable knowledge and communicates it to the society in a one-way fashion. Dissatisfaction with the 'ivory tower' of science means the old 'social contract' is giving way to a new contract, the shape of which is still not clear. This is also related to the view that alternative sources of knowledge production that are non-academic, non-disciplinary, and more grounded in social problems have been emerging in relation to the upsurge of non-governmental non-profit social organizations. Green movements, patient associations, and traditional knowledge communities are today collecting, processing, and using sophisticated knowledge, which complements (and sometimes challenges) conventional scientific knowledge (DESAI, 2007). This is a 'mode-2' of knowledge production that departs significantly from the 'mode-1' of self-contained scientific academia (GIBBONS et al., 1994).

The second front involves the changing nature of governmental involvement in the specific field of science and technology policy. Among the most important are changes in the forms of funding of research conducted at universities, public research organizations, and firms (LEPORI et al., 2007); new forms of management requirements (RIP, 1994); and changes in the mechanisms for verifying science's integrity and productivity (GUSTON, 1996). In a sense, the changing nature of governmental involvement in the core organizational dimension of science and technological knowledge production is not only related to the styles and instruments of science policy, but to a large extent also to the changing boundaries between governmental action and the self-organized dimensions in the governance of knowledge production.

The third front involves the ownership of scientific–technical knowledge. Merton's ideal feature of science's disinterestedness (as a non-commercial altruistic concern with the benefit to humanity) is largely based on a notion of openly available and free science. However, there has been an increasing tendency towards the privatization and commodification of knowledge (particularly academic knowledge), in a way that is far from being seen as socially, economically, and normatively unproblematic (CALLON, 1994) (JACOB, 2009). The scientific community itself has also been concerned with this. The privatization of knowledge might pose problems for the methodological robustness of the scientific endeavour because data cannot be exchanged nor the results of scientific analysis verified. This is behind the scientific community's own mobilization to support the idea of 'open science', in what seems to be a return to the Mertonian ideal of self-organized science.

What the three 'fronts' above show us with all clarity is that the tension between the self-organization of S&T and the politics of purpose (either governmental or commercial) has been exacerbated during the past years. Most importantly, perhaps, they show us that this has resulted in a multitude of different institutional arrangements. Institutions like peer review, increased power of research councils, and non-commercial mechanisms of knowledge dissemination have been reinforced and co-exist with a series of new institutional arrangements like centralized scientific verification instruments, competitive sources of research funding, and commercialization of public research outputs, in what seems to be a 'push' towards more purposefulness of S&T with a parallel strengthening of the institutions based on the ideal of S&T self-organization. This means that the

governance of S&T is today more heterogeneous and complex than it was a few decades ago, and that the general shift to 'governance' has run parallel with a visible governmental action.

3.- Regulating New Technologies: Markets, Networks, or Hierarchical Coordination

The coordination of new technologies and their use in the society and economy is a major issue in the governance of S&T. Problems of coordination might be particularly important in technologies where there is a high degree of technical interdependency (interoperability) and high levels of positive network externalities (the more members joining, the lower costs for all, but with high costs for individual defectors or 'orphan users'). In such cases, striking the balance between the opportunities of the economies of scale that the positive network externalities offer and the risk of technological/economic lock-in (sub-optimal technical/economic solutions 'trapped' in such arrangements) is particularly convoluted. From the perspective of governance, a tension emerges in terms of different modes of coordination, namely between the market, network, or hierarchical coordination of these technologies.

One field where tensions related to coordination mechanisms are most evident is technical standard-setting. Virtually all products today have to comply with a series of product specifications of a technical character. Yet, when looking at how these are defined and implemented, there is a wide range of forms of coordination mechanisms. Unilaterally defined standards are forms of hierarchical coordination, either because the standard of one producer dominates the market (like Microsoft's operating system 'Windows') or because a single government has unilaterally legislated and defined an obligatory technical standard. Fewer hierarchical forms of coordination are more common. For example, technical standards concerning safety and consumer protection in Europe are typically defined in a broad legislative mandate that is further negotiated in independent standardization organizations by networks of governmental officials, producers, and consumer representatives. Other more privately driven forms of coordination are to be found in the so-called 'sponsored standards' where firms hold proprietary interests and define the standard collectively (like in the DVD case). Yet, the definition of standards is far from being a technical matter: it is a highly political matter, particularly in the international context because standards are associated with trade matters (MATTLI and BUTHE, 2003). In some cases, the shadow of the state in those international standardization processes might be very long (ABBOTT and SNIDAL, 2009).

Another field where interoperability is most remarkable is information and telecommunication technologies (ICT). Here the tensions related to coordination mechanisms refer to the (de)regulatory frameworks defining the patterns of economic interactions and incentives, as well as the competitiveness and dynamism of this strategic industrial sector. The regulation of the ICT sector since the mid-1980s has been highly linked to privatization and liberalization trends in national contexts, and therefore part of the efforts to create regulation-for-competition in a new and rapidly changing industrial context (LEVI-FAUR, 1999) (JORDANA and LEVI-FAUR, 2004). There are different models of regulatory frameworks for the ICT sector, and some are perceived to be more effective than others depending on their ability to coordinate interoperability efficiently and dynamically by stimulating ICT standards, their ability to spur innovation and technological development in a decentralized manner, and the way in which information within the regulatory framework is collected and distributed. Yet, the ICT revolution since the second half of the 1980s is

not only the story of a generic and disruptive technology. It is also the story of technological advancements that are largely shaped by the wide societal dynamics (MCDOWELL et al., 2008).

The diversity in the mechanisms of governance (market, network, hierarchy) and the tensions between them, as described above, are also observable in other science–technology-intensive areas, for example the life sciences or aerospace, which have different features in terms of interdependency and externalities. Furthermore, when looking at the regulatory aspects of science, technology, and innovation governance, it is most important not to forget crucial cross-cutting regulatory issues like intellectual property rights, phytosanitary codes, or environmental standards. Social studies in these fields point at important issues regarding the different bottlenecks and effectiveness of national regulatory frameworks on the patterns, flows, and use of knowledge. Regulatory frameworks of intellectual property rights are of particular importance because they have an all-encompassing effect on the economic regimes of knowledge appropriation, so fundamental to science–industry relations and innovation processes. More specifically, patent regulations have been recently under the critical scrutiny of economists at the national (JAFFE and LERNER, 2004), regional (GUELLEC and VEN POTTELSBERGHE DE LA POTTERIE, 2007), and international levels (DRAHOS and BRAITHWAITE, 2002) regarding the extent to which they strike a balance between the private interests of patent owners and the overall social gains of the patent system. This is ultimately a balance between the public and the private, and between different modes of governance.

Again, what the regulation of new technologies tells us is that the tension between hierarchical, network, and market-based forms of coordination has increased during the past years, and that different arrangements co-exist in time and place under a general trend towards 'governance'.

4.- Techno-Scientific Knowledge and Democracy: Experts or Citizens?

When dealing with the governance of science and technology another fundamental tension deserves our attention, namely the roles of techno-scientific experts and of citizens in contemporary liberal democracies. Recalling previous chapters in this book, governance has to do with the identification and solution of collective problems. Hence, the way in which scientific knowledge interacts with citizens, and the democratic nature of the procedures that define such interaction, are central parameters for the ultimate legitimacy of those collective efforts. Having said that, however, the way of articulating the interaction of citizens–experts and establishing democratic procedures is a highly complex matter: firstly, because there are different normative theories of democracy with significantly different views on what democracy is; and secondly because empirical analysis tells us about an overwhelming number of co-existing institutional arrangements within and across advanced liberal democratic systems.

A rapid examination of the burgeoning literature on science and democracy shows that the most dominant propositions can be characterized according to two important parameters, namely their anchorage on normative theories of representative or participatory democracy and on their different views regarding the empowerment of citizens or experts. These two dimensions involve the different models of democracy as alternative institutions of voice (RON, 2011), and are also based on the recent creation of more elaborate procedures for representation and participation (FISCHER, 2011). This results in the following matrix:

Table 1: Normative theories' views on the democratic dimension of socio-technical knowledge

	Empowering citizens	**Empowering experts**
Representative democracy	Improving the public understanding of science for an informed public debate.	Ensuring 'sound science' in agencies with effective problem-solving capacity
Participatory democracy	Actively participating 'science citizens' generating deliberation.	Participation of a wide range of experts producing 'socially robust knowledge'.

Taking the first row of the table, normative theories of representative democracy tend to address this issue either from the empowerment of citizens or from the empowerment of scientific experts. In the first case, the focus tends to be on empowering the citizens through the provision of careful scientific information and communication. Fostering the public understanding of science (MILLER, 2001) will allow for an informed public debate on crucial science–technology decisions. Those advocating the empowerment of experts instead see the delegation of decision-making to non-majoritarian independent regulatory agencies run by scientists as being of the utmost importance. The production of 'sound academic science' within those agencies and its subsequent problem-solving capacity (even in contexts of uncertainty) will generate output legitimacy in advanced democracies (MAJONE, 2010).

From the point of view of participatory democracy this issue is again regarded differently. Considering those who advocate the empowerment of citizens, the crucial issue is to ensure their constitution as 'science citizens' and their engagement in participatory mechanisms that generate deliberation (HAGENDIJK and IRWIN, 2006) (LIBERATORE and FUNTOWICZ, 2003). Last but not least, those focusing on the empowerment of experts see the rise of knowledge associations and their 'expertization' as the crucial issue (TURNER, 2003). Widening the notion of expertise including not only conventional academic science but also knowledgeable experts from NGOs, patient organizations, and the like will produce the 'socially robust knowledge' that advanced liberal democracies need (NOWOTNY, 2003).

The tensions between the role of citizens and that of experts have augmented during the past few decades, as seen in the multiple scientific controversies like the safety of genetically modified organisms, concerns regarding xeno-transplantation, or the food scandals of BSE (mad cow disease) and dioxin levels in food. Seeking to accommodate democracy and scientific-technical knowledge many countries have introduced a number of new institutional arrangements, often of a participatory nature (HANSEN, 2010). The design of these institutional arrangements shows considerable diversity, as it can be linked to those different normative principles. For example, normative world views are behind the USA's preference for independent regulatory agencies (delegating decisions to scientific experts), in contrast with the European preference for 'advisory-only' agencies (JASANOFF, 2005). However, no matter how clearly defined state philosophies might appear, the

myriad of new institutional arrangements during the past two decades demonstrates an increasing heterogeneity of solutions within each country, not only across countries. This institutional complexity underpins the argument of an overall shift towards more varied forms of governance beyond the traditional 'government' forms.

5.- Studying the Effectiveness and Legitimacy of S&T Governance

The previous sections have illustrated the omnipresence of science and technology in our contemporary societies, and the persistent tensions in the governance of S&T. The main argument of this chapter is that the tensions implicit in the governance of S&T have become more intense during the past few decades. This reflects a process of transformation from government to governance, as the institutional arrangements organizing science and technology and their interactions with the society and economy have multiplied and become more diverse and heterogeneous. Besides, this multiplication and increasing hybridity of the institutional arrangements in the particular field of science and technology supports the notion of a co-expansion of governance and government suggested in the introduction of this handbook (LEVI-FAUR 2012).

The question that naturally arises from this is whether this multiplication and heterogeneity of institutional arrangements is having a positive or negative impact in terms of the effectiveness and legitimacy of S&T governance. The extensive literature in science and technology studies in the fields of economy, sociology, and political science has taken different stances on this matter. However, the strong disciplinary boundaries have generated some remarkable blind spots. In the light of the tensions described above, it is my personal interpretation that two aspects regarding effectiveness and legitimacy deserve further academic attention.

The first aspect for a research agenda has to do with a new analytical perspective on 'effectiveness'. Economists tend to discuss issues of effectiveness in terms of Pareto optimality, namely a situation in which no individual can be made better off without making another individual worse off. Furthermore economists have considered effectiveness as being opposed to issues of 'market failure' and/or 'government failure'. These are related to the malfunctioning of markets and governments due to a series of possible problems. Yet, whereas the economists' perspective is an attractive one when considering effectiveness, it is still not sufficient to understand the when, how, and why some institutional arrangements in the governance of S&T are better than others for creating the expected outcomes and avoiding systemic bottlenecks. The problem is that the notion of optimality is based on a single understanding of rationality, and it does not take into account the multiplicity of axioms of social behaviour and the corresponding multiplicity of the socio-economic and political context in which S&T governance is embedded. For that reason, a research agenda that studies the effectiveness of the new and heterogeneous institutional arrangements in the governance of S&T needs to have a broader analytical framework, anchored not only in notions of 'bounded rationality' but also in the understanding that institutional arrangements are effective if they are able to shape/be shaped by social behaviour in a particular way. In this sense, studies of effectiveness need to take into account the diversity of socio-cultural contexts, and the way in which society and the economy shape the organization of science and technology (and vice versa). One possible starting point in that regard could be to anchor research about the effectiveness of S&T governance on the literatures of socio-technical systems (GEELS and SCHOT, 2007), of innovation systems (EDQUIST, 1997), and of regulatory systems (BORRÁS, 2006b). These systemic approaches allow the examination of the effectiveness of individual institutional arrangements within the context of

their wider institutional frameworks. Yet, even if these systemic approaches are proving very fruitful in avoiding analytical traps of 'one size fits all', their empirical endeavours have far too often focused on single-case studies with little generalizability. Therefore, if a research agenda looking at the effectiveness of complex institutional arrangements from a systemic approach is to take off, it will require more decidedly cross-country and cross-temporal comparative studies to distil the theoretical consequences of broader empirical research.

A second important aspect in a renewed and more interdisciplinary research agenda would be to reconsider the dominant analytical perspectives on questions about the legitimate governance of S&T. The normative approaches examined in the previous section have provided very rich and suggestive alternative normative solutions for the tension between experts and citizens in the search for a legitimate and democratic governance of S&T. However, this large literature has tended to address these issues more normatively than empirically. Just as above, this literature has plenty of examples of single-case studies, typically from the developed world and typically with a micro-level methodological approach. These rich but empirically limited studies in many cases focus heavily on the normative dimension of the case, rather than on its empirical value in terms of generalizability. However exciting, this methodological choice suffers from some important limitations in terms of bringing forward the 'lessons' of a multiplicity of situations and contexts where the governance of S&T is (or is not) perceived by the people to be democratically legitimate. This calls for undertaking more decidedly broad empirical efforts in this area, putting emphasis on the use of a wider range of methodologies (quantitative and qualitative), as well as cross-country and cross-temporal comparative studies. Such an empirical turn should be based on the understanding that the democratic legitimacy of S&T governance is based not only on the question of the extent to which reality complies with a theoretically and deductively defined understanding of legitimacy, but also the extent to which it corresponds to the on-the-ground popular support for it. This is so because at the end of the day normativity is not only defined by social scientists, but is to a large extent defined by a popular feeling of what is just and democratic (and what is not). Therefore a new research agenda would need to put more emphasis on empirical studies of popular attitudes, preferences, and behaviours regarding what is perceived to be a legitimate governance of S&T. In so doing, this new empirical turn in the study of the legitimate governance of S&T will provide useful inputs to the normative approach by pointing at changes in popular trends and behaviours, and by considering the extent to which some of the normative theories' assumptions hold true (BORRÁS et al., 2007).

All the remarks above serve to underline that studying the tensions in the governance of S&T, and the institutional arrangements set up to deal with them, needs to be addressed from a multi-disciplinary approach. Political science, economics, and sociology offer considerable opportunities for combining insights into what is ultimately an empirical research agenda of one of the most fundamental dimensions that characterize the history of humanity and its organization, namely science and technology.

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