Governance and Organisation of Research Infrastructures

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Abstract

This chapter examines Research Infrastructures (RIs) as complex, socially constructed meta-organisations that bring together autonomous yet interdependent partners. It explores the governance challenges arising from coordinating distributed nodes, managing common-pool resources, and balancing collective and individual interests. The chapter reviews key governance models adopted by European RIs, highlighting how formal rules, decision-making bodies, and organisational arrangements shape effectiveness and legitimacy. It argues that robust, multilayered governance is essential for sustaining collaboration.

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1 Research Infrastructures as Complex Organisations[1]

On its website dedicated to Research and Innovation, the European Commission (2020a) presents a brief description of RIs, defined as 'facilities that provide resources and services for research communities to conduct research and foster innovation'. It notes that these facilities can be utilised beyond research, for example, in education, public services, and industry, and may take various organisational forms, which it categorises as single-sited, distributed, or virtual.

RIs often display a translocal character and an international configuration. The Organisation for Economic Co-operation and Development states that an International Distributed Research Infrastructure (IDRIS) is 'a multinational association of geographically-separated distinct entities that jointly perform, facilitate or sponsor basic or applied scientific research' (OECD, 2014: 7). In every case where geographically distributed organisational entities come together to cooperate and form a supra-organisational institution, a new and more complex meta-organisation emerges. The result may be the establishment of scientific umbrella organisations, clusters, consortia, or other collaborative and networked research facilities. Such new types of research facilities 'pose specific problems' (Meijer et al., 2012: 492), particularly in terms of structure, governance, coordination, and decision-making. In any case, the issue not only pertains to the emergence of a new kind of knowledge organisation but also of highly complex social units in terms of goals, technologies, structures, coordination, communication, and decision-making processes. If two decades ago R&D organisations were considered unique in terms of the coordination needs of people, ideas, funds, and culture, including the difficulties of managing autonomous researchers and creative working processes that might seem unmanageable (Jain & Triandis, 1997:19), we have to stress the magnitude of the organisational challenges now facing RIs in a knowledge-based global society. Sharing information, research data, scientific resources, and artefacts, as well as providing services and products on a large scale, are new functions that add complexity to RIs and raise unexpected demands.

1.1 Knowledge Organisations as Socially Constructed Units

RIs can host a wide variety of resources, including collections, archives, biobanks, libraries, museums, telescopes, research vessels, satellites, computing systems, and communication networks. Every scientific resource makes a difference in terms of its impact on organisational technologies, i.e. the processes used to achieve particular goals. In addition, the different scientific, technological, social, and cultural fields, as well as the diverse scientific communities and their specific epistemological and methodological paradigms, codes, and rules, strongly influence

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organisational design, including such elements as structures, work processes, types of leadership and coordination, power relations, autonomy, and decision-making.

However, there is nothing natural in RIs and the above-mentioned impact cannot be understood in deterministic terms. Everything is the result of historical and social processes of construction that underscore the artificial character of RIs. As socially constructed units, RIs are neither 'things' nor anthropomorphic purposeful actors, but rather, dynamic organisations made up of people, always in process, creating and recreating structures and rules through human agency.

Biobanks, for example, may show evidence of several organisational elements that are influenced by scientific codes and professional cultures and subcultures rooted in biology. Even some organisational theorists, especially contingency theorists, have treated organisations as biological organisms. It was a metaphorical way of trying to understand organisations as living systems (Morgan, 1986: 39–76), well adapted to specific environments, surviving through the process of satisfying their needs and aspirations. But the organism metaphor has been much criticised for its reification of social and formal organisations, which are not natural beings but rather social, cultural, and political constructs. Accordingly, they show the capacity to intervene in the social environment and not just adapt to it, to choose values and policies, to change norms and rules, to cooperate and reach consensus among groups and subgroups, and to develop power relations and conflicts.

That is why the different organisational concepts we need in order to make sense of RIs are cultural and historical expressions of social theory's plurality. They are analytical tools that help us denaturalise RIs, not just as instruments to produce or to achieve something (the Greek 'organon'), but as institutions and cultural and social phenomena that are the result human agency. They are quite different from the concept of organisation related to the solar system, atoms, or cells that are not social actors with specific agendas, interests, and preferences.

1.2 Organisations in Action

Understanding RIs requires the use of two different meanings of the word organisation. On the one hand, 'organisation' as a noun is used to refer to an historically constructed social unit for achieving a minimum of cooperation between people, groups, and subgroups. This is indispensable for accomplishing work and producing goods and services in order to guarantee the 'attainment of specific goals', according to the functionalist definition of Amitai Etizioni (1961: xi). On the other hand, there is a second and more dynamic meaning of organisation that involves organisation as organised action or, simply, organisation in action and the activity of 'organising' (from the verb 'to organise'). Both meanings are crucial for the study of the organisational world: the social structure and the social action in their relationship of interdependence.

Since organisational theory offers no universal definitions due to the theoretical pluralism that marks the social sciences, the result is the plurality of organisational concepts. As Czarniawska-Joerges (1992: 17) reminded us, 'pictures of complex

organizations change depending on the standpoint'. This is why the organised action performed by RIs can be interpreted in considerably different ways. At times, interpretations highlight the rational-formal elements, the standardisation of procedures, the close relationship between means and ends, and the formal structures and rules that result from more or less consensual processes of coordination. This is generally the view based on the sociological concept of bureaucracy or rational-legal authority as defined and criticised by German sociologist Max Weber (1947) in the early twentieth century. In other cases, however, lack of consensus on objectives, the existence of unclear technologies, and more ambiguous and probabilistic than formally rational decision-making processes offer us both distinct and complementary interpretative frameworks. Theoretical approaches based on the ambiguity of goals, the uncertainty of technologies, and the fluidity of participation portray organisations as 'organised anarchies' (Cohen & March, 1974) and not only as rational bureaucracies. Different patterns of order, organisation, and rationality may, however, be combined when studying RIs and seeking a deeper understanding of its dynamics.

There are often conflicts regarding organisations' goals and differing views about their official goals in particular. Important elements for understanding RIs are statutes and regulations as well as the formal structures that usually give rise to the design of methodically arranged organisational charts. But these formal views tend to be more static and official than dynamic and real. RIs in action can move considerably away from formal structures and rules through informal processes, structures, and rules that do not appear in the organisational chart. Yet these social phenomena have the capacity to change and recreate organisations, and that is why there is no theoretical advantage in treating them as simple deviations, dysfunctions, or irregular courses of organised action. Just as the pipe painted by Belgian surrealist painter René Magritte is not a pipe (*Ceci n'est pas une pipe*), but simply the pictorial representation of a pipe, so the organogram of an RI is not the RI, but only a representation of the formal structures of that particular organisation. Organised action, decisions, communication, and power relations occur in the interstices of the formal representation of the RI.

1.3 Coordination and Decision-Making Processes

RIs pose new problems of coordination, especially in the case of distributed infrastructures, which include other types of internally networked facilities, namely cyberinfrastructures. Also, depending on their size and scope as well as on policy, geographically distributed RIs tend to be more demanding than single-sited RIs in terms of coordination of their nodes. However, careful examination is required with respect to the widespread idea that single-sited facilities are by definition centralised and more bureaucratic, while distributed infrastructures tend to be decentralised and post-bureaucratic. For instance, Meijer et al. (2012: 494), when referring to some biobanks, stated that 'fully centralized facilities have a single location for samples and a unified management structure physically located at the same site'.

However, in fact, much depends on the coordination mechanisms that are adopted, similar to hierarchies, markets, or networks for example. As Barjak et al. (2013: 118) observed, 'in networks, actors are not as independent as in markets, but less interdependent than in hierarchies'. The concept of coordination, traditionally associated with control, may however comprise multiple degrees of articulation between components of the organisation as well as between objectives and actions, superiors and subordinates, and among national nodes of the same international infrastructure. RIs are not always 'rationalized, tidy, efficient coordinated structures' (Weick, 1976: 3), that is, 'tightly coupled systems'. They include elements that also allow us to understand them as 'loosely coupled systems', as organisations in which 'each event also preserves its own identity and some evidence of its physical or logical separation' (Weick, 1976: 3). Therefore, strong hierarchical coordination based on heteronomous control is not indispensable for holding together a minimally integrated and responsive RI.

In distributed infrastructures, the organisational configuration adopted may be more closely associated with the structural distribution of its nodes, showing an apparent or merely morphological decentralisation, best understood as a deconcentrated configuration. In such a case, apparent morphological decentralisation is no more than the result of a constellation of geographically dispersed partner organisations or units. That organised dispersion may be fully compatible with the centralisation of decision-making power. In tha case, power is little shared and poorly participates in decision-making terms, relatively independent from the structural configuration. In contrast, it is possible to find single-sited infrastructures whose structures of authority are participative and where the exercise of power is internally decentralised, giving considerable autonomy to social actors, departments, and units. In such circumstances, however structurally concentrated, those infrastructures may be considered internally decentralised and to some extent polycentric in terms of decision-making power. Organisational design, formal structures, authority, and power relations cannot be understood separately. That is why unified or concentrated infrastructures may be morphologically centralised into just one site, but decentralised when it comes to the autonomy of its internal units and the power of their social actors to participate in decision-making.

1.4 Just Tools in Search of Utility?

It is not possible to implement scientific policy or a large-scale research service project without resorting to an organisational apparatus. While RIs are, in this context, instruments for carrying out a specific policy programme, they are in fact far from being just technical tools in search of utility. They are also social and cultural organisations that tend towards their institutionalisation over time. Among the various institutional profiles that may emerge, three deserve mention: RIs as hierarchies, markets, and communities.

As hierarchies, RIs display elements such as instrumental rationality, order, and centrally defined universal rules. Centrality tends to be assigned to monocratic

leadership, assisted by strong 'technostructures' that consist of professional advisors and other technical staff.

The market is the privileged form of institutional legitimation of RIs as market-oriented organisations. Legitimisation occurs through economic rationality, competition, flexibility, and some degree of deregulation, along with the commodification of research services and products according to an 'entrepreneurial spirit'.

Finally, as communities, RIs tend to display the sharing of goals and values, beliefs, and attitudes, through processes of socialisation, integration, and participation of their members.

The three schematically mentioned institutional profiles promote different processes of legitimation and, to some extent, the negotiation of different orders, values, norms, rituals, and organisational conceptions of RI. In practical terms, these profiles are more complementary than mutually exclusive. The community profile may require more dialogue and participation, but the values of democracy and participation are crucial to the processes of legitimation of all scientific and knowledge organisations. This is especially true for those that depend most on their reputation and social status to the public, on governmental and community budgets, and on participation of the general public, particularly the public in direct contact with the organisation. Insistence on institutional profiles based on other forms of bureaucratic domination, such as hierarchy and control, as well as on strict utility patterns in pursuit of maximum profit, can be highly questionable options for RIs. The advocacy of democratic values, ethical debates on science and its technological applications, public fundraising campaigns, and social movements in defence of human and environmental rights are increasingly relevant phenomena. Participation in terms of representative democracy and certain forms of small-scale direct democracy, including collaborative and consultative processes—especially in policymaking processes within RIs—is crucial for democratic governance and acceptance by the public.

Note also that democratic governance of RIs cannot guarantee processes of dialogue and active participation by members of the organisation, and not just in terms of information sharing, suggestion gathering, and other forms of low-intensity engagement. Participation in policymaking is irreplaceable for realising the utopia of a democratic 'scientific community' not only at the political level of the European Union Research Area (Ryan, 2015) and its member states, but also at the heart of each RI.

2 Governance in Research Infrastructures

2.1 Meta-Organisations and the Role of Governance Arrangements

RIs may share some features with all three of the institutional profiles described above, depending on their mandate, history, funding mechanisms, whether they are single-site or distributed, and other relevant factors. It is clear, though, that they

fully correspond to neither hierarchies nor markets; instead, they correspond more closely to communities, networks, or clans (Ouchi, 1980). An important implication is that they cannot be managed primarily through centralised, top-down mechanisms, like superimposed procedures in hierarchies, nor through decentralised, arms-length mechanisms, like price signals in markets.

RIs share this feature with the growing number of organisations labelled as 'meta-organisations', i.e. organisations whose members are other organisations instead of individuals (Ahrne & Brunsson, 2005, 2008; Berkowitz & Dumez, 2016). Not only is the definition of RIs a close match to that of meta-organisations (OECD, 2014: 8), but their typical features also match, as described by Ahrne and Brunsson (2008: 3):

> The members have considerable autonomy. They have applied for membership by choice, and they are free to leave at any time. They cannot be forced to become members or be purchased. And as members they keep most of their autonomy and identity as independent organizations. Furthermore, in meta-organizations, as is typical for associations, members are equals.

The presence of independent organisations as part of a meta-organisation poses a specific challenge for the management of both RIs and their partners: balancing the collective interests that led to the establishment of that infrastructure with the specific objectives pursued by each partner. In a context characterised by interdependency, self-interested partners may make choices that appear rational from an individualistic perspective but ultimately lead to outcomes that leave everyone worse off. Short-term wins can trigger adverse consequences and ultimately long-term losses. This phenomenon is described in the academic literature as a collective action problem (Olson, 1965) and is especially common in the presence of 'common-pool resources', i.e. assets characterised by joint use and subtractability (withdrawal by one partner reduces the amount left for others). Opportunistic behaviours result in the 'tragedy of the commons' (Hardin, 1968), defined as a failure to avoid joint losses and the inability to secure joint gains.

This risk can be addressed by centralised governmental regulation or by privatisation, but these options are obviously incompatible with the very nature of RIs. The only option left is for partners to learn how to 'govern the commons' (Ostrom, 1990), i.e. by agreeing upon and enforcing durable cooperative arrangements that allow joint use of common-pool resources to take place in a way that keeps meeting collective objectives over time while balancing the legitimate interests of individual partners. In international relations, these arrangements among interdependent players are labelled as international policy regimes (Krasner, 1983: 2), but very similar arrangements must be developed in order to secure the governance of RIs.

Designing effective governance arrangements for joint use of common-pool resources and making sure they work have been explicitly identified by the European Commission among the most important points for the development of European RIs (European Commission, 2020b):

> State-of-the-art research infrastructures become increasingly complex and costly, often requiring integration of different equipment, services and data sources, as well as extensive transnational collaboration. (…) It is not only necessary to avoid duplication of efforts and to coordinate and rationalise the use of the facilities, but also to pool resources so that the Union can also acquire and operate research infrastructures at world level.

The importance of governance arrangements cannot be underestimated. Not surprisingly, they are often a source of disagreement, or even of conflict, among partners in an RI. For this reason, it is important to understand what challenges entailed and what solutions are available to tackle them.

2.2 What Is Governance?

The concept of 'governance' is commonly used in multiple fields of inquiry, ranging from public administration to international development. As a consequence of the multiple contexts in which it can be applied and the various perspectives through which it can be explored, defining what governance means is not straightforward. Let us begin with the problem governance is designed to address. Most societal challenges cannot be solved single-handedly by individual public authorities, through direct interventions, orders, or prohibitions. Because of their intrinsic nature, challenges such as climate change, environmental protection, or economic development require the voluntary engagement of multiple stakeholders, including other public authorities, NGOs, industry associations, and the media.

Governance is broadly defined as a 'non-hierarchical mode of governing, where non-state, private corporate actors (formal organizations) participate in the formulation and implementation of public policy' (Mayntz, 2006: 18). The presence of multiple, often heterogeneous stakeholders is intrinsic to RIs. According to the definition used by the OECD, RI partners include 'funding agencies, research institutes, academic institutions, foundations, or other research-oriented organisations from the public or private sectors' (2014: 7). Similarly, Edwards et al. define the broader concept of knowledge infrastructures as 'robust networks of people, artifacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds' (2013: 7).

This 'non-hierarchical mode of governing' has often been touted as a miracle drug. Its proponents point out that it yields superior results, as it allows for the processing of more information, takes a broader variety of values into account, overcomes the risks associated with veto powers, builds trust and a shared vision among network participants, and, in short, makes 'better' decisions. Reality is more complex. First, not all stakeholders are created equal: they hold different amounts of information and resources, different degrees of interest, different ability to influence outcomes, and different levels of accountability. Secondly, their interests may be at odds: compromise can be the only way to keep them on board, but it may not necessarily be the best answer to societal challenges.

The way governance works, therefore, is essential for solving complex, multi-stakeholder issues. If governance is effective, then relevant stakeholders are on board, they collaborate effectively, and societal challenges are addressed efficiently. If governance is ineffective, problems remain unresolved and often worsen.

The concept of 'good governance' has been discussed at length to distill the tenets of sound multi-stakeholder decision-making. A set of eight principles has been identified by international organisations as the gold standard for good governance: respect of the rule of law, transparency, responsiveness, consensus orientation, equity and inclusiveness, effectiveness and efficiency, accountability, and participation (Young, 1999). These principles can be used as benchmarks to identify areas for improvement in the way governance is practised. They have limited usefulness in operational terms, however, especially because they are often at odds with each other.

The essence of good governance is defining suitable 'rules of the road' to facilitate interaction among different players. Effective governance is a matter of both mechanisms and management patterns, which are obviously related and deserve separate discussion.

Mechanisms are the formal rules used for decision-making. When referring to RIs, 'governance' is usually intended as 'institutional' or 'corporate' governance, i.e. the framework for decision-making established in the formal agreement that created the RI. The framework for decision-making encompasses various elements, including its mandate, the roles assigned to the General Assembly, the Director, the Secretariat, and the Scientific Advisory Board, as well as the presence of committees, voting mechanisms, and funding criteria. An overview of the corporate governance mechanisms used by European RIs is featured in paragraph 3.3.

Good governance is not determined only by formal rules, though. A systematic review of the empirical evidence in multi-stakeholder decision-making identified three sets of variables that influence effectiveness (Ianniello et al., 2019). First, contextual factors, including, in particular, information asymmetries among network participants, play a role. Secondly, formal arrangements are obviously relevant. Especially important among these are the mechanisms agreed upon to engage multiple players in the pursuit of a shared decision, stakeholder representation criteria, and the design of the process. The third set of variables is represented by process management patterns, including group dynamics and collaboration quality; although they may not be formalised, they have a significant impact on whether the involvement of multiple stakeholders actually delivers better solutions. These variables indicate that governance is not only a matter of rules, but also that managers and management patterns play a crucial role in addressing complex, multi-stakeholder challenges, such as the effective functioning of an RI.

2.3 Governance Patterns

A wide range of governance patterns can be observed when examining RIs. We focus here on two features of these patterns: the form of the network whose resources are pooled in an RI and the set of tasks the networks are expected to perform.

Antivachis and Angelis (2014: 588–589) identify three basic forms networks can take. The simplest form is polycentric governance, one that is governed by the partners themselves, without any ad hoc governance entity. The resulting networks tend to be highly decentralised and involve almost all the partners, interacting on a relatively equal basis (shared or distributed governance). This governance pattern assumes the commitment of all or a significant subset of the partners that make up the network. Partners are responsible for managing internal network relationships, as well as relationships with external stakeholders, including customers, the community, government, and funders.

Lead organisation governance (Dhanaraj & Parkher, 2006) occurs when partners share a common purpose, but one partner is more powerful than the rest in terms of size, resources, or legitimacy, allowing it to serve as the hub or central node of the network. Governance in this case is centralised instead of shared. The partner designated to undertake the lead role in network coordination may be mandated by an external funding source or may emerge among the partners, based on who they perceive to be the most effective and efficient network member to fill this role.

The third form of governance entails the presence of a dedicated Network Administrative Organisation (NAO), which is a separate central facility established, apart from network partners, with the sole purpose of governing the network and its activities (Provan & Kenis, 2007). In this case, the network is externally governed, with the NAO established either by mandate or by network partners themselves for the specific purpose of governing the network. NAOs may range in size from a single individual (the network facilitator or broker) to a formal organisation operating out of a physically distinct office with a CEO and dedicated staff.

Shared governance is typically preferred by partners, as it enables them to maintain control over the network's direction. It is most suitable when the network size and complexity are limited, and partners are similar to one another and generally agree on the goals the network should pursue. Antivachis and Angelis (2014: 590) argue that shared governance tends to become ineffective when task requirements are high because network members may not possess the required skills (e.g. communication, fundraising, lobbying). On the contrary, these conditions may favour central coordination through either the lead organisation or NAO governance forms, which are better able to develop or acquire the specific skills needed to ensure effective network governance. Obviously, more articulated solutions can be envisaged. One example is multiple operational hubs organised as national networks with a central coordinating mechanism that can be supported by one or more nodes or an NAO (OECD, 2014: 10).

A different feature of governance patterns is the nature of the institutional tasks that networks are expected to perform. This feature is relevant when analysing RIs because the activities they facilitate may be meant to support different tasks. Young

(1999) suggests a useful taxonomy in this respect, distinguishing regulatory, procedural, programmatic, and generative tasks. Regulatory tasks are the most visible. They entail the definition of the rules meant to allow participating actors to avoid joint losses or reap joint gains in situations characterised by interactive decision-making. In international relations, these rules are enshrined in treaties, conventions, and other high-profile formal arrangements. If the policy issue to be addressed is overfishing, the EU Common Fisheries Policy is a good example.

Treaties and conventions are important, but they establish broad principles that are often unsuitable for immediate implementation. Ad hoc mechanisms are necessary to make informed decisions regarding the challenges that arise when translating those principles into practice. Procedural tasks entail the administration of these mechanisms. Using the example of overfishing, it may be important to determine whether certain species should be added to the list of endangered species, thereby granting them additional protection. At times, choices are required on a regular basis, such as setting maximum catch levels for the following year.

Programmatic tasks involve establishing multi-stakeholder initiatives aimed at deepening or broadening knowledge about issues of common interest. At a minimum, concern regarding overfishing indicates that a common data collection system must be designed and implemented to assess whether the rules agreed upon are having the intended impact on fish stocks. Over time, data collection could be extended to related aspects; for example, it may be important to understand whether climate change has an impact on fish stocks, so as to determine whether maximum catch levels should be set differently.

Last but not least, generative tasks entail the establishment and merging of official and unofficial, national and transnational groups, which provide support for the development of a given regulatory framework. A component of this process is refining the conceptual frames used to discuss a given issue. For instance, early fishery regimes pursued the idea of 'maximum sustainable yields' (MSYs). More recently, the discussion of 'ecosystem management' has replaced MSYs, emphasising the interplay between harvested species with biotic and abiotic settings.

RIs are typically established to work on programmatic tasks, but they may also play a significant role in procedural and generative tasks, and ultimately may end up supporting regulatory tasks as well, especially if the latter evolve into fully developed knowledge infrastructures. As an example, LifeWatch ERIC claims that 'understanding the evolution and functions of biodiversity and ecosystem services is now of crucial importance, not only for scientific reasons, but also to meet the demand from policy makers, managers and stakeholders for scientific-based tools,' and it explicitly includes in its mission, 'supporting knowledge-based decision-making for biodiversity and ecosystem management' (LifeWatch ERIC, 2020). The actual combination of tasks performed by an RI often evolves over time based on the priority given to a set of goals, although all tasks play an important role in addressing collective action problems effectively.

3 Formal Governance in Research Infrastructure

3.1 Governance Mechanisms, Rules, and Procedures

One of the most important points in the development of European RIs for 2020 is the reinforcement of international cooperation/collaboration (European Commission, 2020b). This cooperation is vital and must be strengthened with lasting and stable agreements between the nations concerned. These agreements should take into account international differences, national objectives, but in particular, they should identify an effective system of governance (OECD, 2008, 2010).

Formal governance is the formality of governance that should be used in infrastructure (Barjak et al., 2013: 119; OECD, 2014: 11). Formal governance is characterised by material incentives, legitimacy based on rules and routines established and strengthened in contracts or binding agreements, and vertical relationships in which control is exercised by higher positions in the hierarchy (Barjak et al., 2013: 118).

Leaving aside 'material incentives', which can be of different types and refer to revenues or other resources, lower costs, opportunities for future development, etc., the other two characteristics will be examined in order to analyse which of them constitutes major governance challenges for an RI. Therefore, we will focus on the legally enforceable rules and routines established in contracts (i.e. their various legal frameworks) and the analysis of vertical hierarchical relationships (particularly the structures of governance bodies and their relationships).

According to the ESFRI Roadmap 2018, governance models for RIs should define the roles and commitments of all the different stakeholders[2] with respect to a coherent and consistent funding landscape throughout the RI lifecycle. Based on the definition of corporate governance for private companies[3] (Cadbury Committee, 1992), it is possible to extrapolate the definition of corporate governance for RIs as 'the set of structures, principles, rules, and procedures used to regulate the entities or organisms that would run RIs'.

There are different types of RIs: single-sited, e-infrastructures, and distributed RI. The latter are, of course, the most complex and will certainly have a more stratified and articulated governance structure. In distributed RIs, the various relationships between nodes and facilities are crucial. For example, there may be distributed RIs where there is a loose connection between the nodes, central coordination between the nodes (with coordinating mechanisms supported by one node or by one or more facilities or by an independent organisation), or a combination of the preceding, in which there are multiple operational hubs and the coordinating mechanisms can be supported by one or several nodes or by an independent organisation (OECD, 2014: 10).

[2] International, European, member states, associated countries, regions, research organisations, research hosting institutions, etc.

[3] The Cadbury Committee (1992) defined corporate governance as 'the system by which companies are directed and controlled".

Table 1 Legal model of RIs

International	**Research infrastructures**	
IGO Inter-Governmental Organisation		CERN, EMBL, ESA, ESO
European		
ERIC European Research Infrastructure Consortium		ACTRIS, AnaEE, BBMRI, CERIC, CESSDA, CLARIN, CTAO, DANUBIUS, DARIAH, EATRIS, ECCSEL, ECRIN, EHRI, ELI, EMBRC, EMSO, EPOS, E-RIHS, ESS, EU-OPENSCREEN, EU-SOLARIS, Euro-Argo, Euro-BioImaging, European Spallation Source, ICOS, INFRAFRONTIER, INSTRUCT, JIVE, LifeWatch, LOFAR, MIRRI, SHARE
National		
LIMITED LIABILITY COMPANIES		
GmbH Gesellschaft für beschränkte Haftung	DE	European X-FEL, INFRAFRONTIER (before becoming an ERIC)
Ltd Private limited Company	UK	EIBIR, SKA organisation, INSTRUCT Academic Services Limited (before becoming an ERIC)
AB Aktiebolag	SE	ESS AB (before becoming an ERIC)
Societé Civile	FR	ESRF
CONSORTIUM		
CA Consortium agreement	EU	GGP—generation and gender programme, AnaEE (national Danish consortium), DISSCo, SIOS (Svalbard), JERICO
ASSOCIATIONS		
AISBL International Belgian Association	BE	PRACE, EuroGOOS, EUFAR
FOUNDATIONS		
Stiftung des bürgerlichen Rechts	D	DESY
Stichting	NL	EGI foundation

Source: Author's elaboration

To ensure legitimacy and identify the best governance scheme for the various types of RIs, it will be necessary to begin with an analysis of the most effective legal frameworks currently in force. Regarding the latter, it is possible to identify the main rules and procedures of governance to be pursued, as well as the bodies responsible for them. During the pre-operational period of an RI, it will be crucial to identify one of the most significant sustainability issues, namely legal status and governance. 'Solid legal forms and corresponding statutes help in securing RI sustainability. Practical solutions should be adapted to the agreed needs of an RI (OECD, 2017: 22).

Table 1 shows the main legal frameworks adopted by most RIs in Europe. They are organised mainly into European Research Infrastructure Consortia (ERIC) or intergovernmental organisations (IGOs), or into alternative national legal forms, primarily Association Internationale Sans But Lucratif (AISBL), according to Belgian law (for an in-depth analysis of legal frameworks in RIs, see Chap. 7 "European Research Infrastructures' Compliance with International and European Law" in this book).

Options for governing structures are linked to the selected legal form (if applicable) (OECD, 2014: 14). Therefore, another important aspect of formal governance is represented by governance structure and vertical hierarchical relationships. A governance model used among the RIs incorporates a general assembly, which is a governing body representing the collective interests of the partners and is the ultimate decision-making body, a director or Board of Directors, in charge of implementing the decisions of the governing body, and a secretariat, which is executive management in charge of operating the infrastructure.

In order to create a more suitable governance structure to address the specific problems of an established RI, a good rule would be to clearly define the governing bodies and boundaries between supervisory and executive structures/functions directly in the articles of association (statutes) or better clarify the hierarchy and relations between the governance bodies. There could indeed be differences between the motivations and interests of associated individuals or institutions that could lead to operational or strategic difficulties. In fact, members of the general assembly are often representatives of governments, while directors or members of the Board of Directors are scientists without particular or high-level management skills. A more detailed division of tasks will therefore allow for a greater ability to separate strategy and control operations from operations management, thus ensuring more fluent and effective management.

Consequently, it is beneficial to have a clear understanding of the bodies that must be established or utilised within RI governance. In general, key tasks assigned to the main bodies can be identified by examining the main statutes of the ERIC, AISBL RIs, or the consortium as a legal framework.

The General Assembly, for example, adopts the annual work programme and budget, approves financial reports and the annual activity report, and approves Agreements and Memoranda of Understanding with Members, and any rules, regulations, guidelines, or other decisions required to ensure the performance. It also elects and dismisses members of the Board of Directors or the Executive Director or Director General, appoints members to other committees, and undertakes any other functions conferred upon it by the statutes, including any annexes or modifications thereto. These tasks represent a deliberative body, responsible for decision-making and control functions.

Having analysed all the RIs in the ESFRI landscape,[4] the tasks are those explained above. However, the denomination of this deliberative body changes from 'RI' to 'RI'. In particular, we can highlight how, both for single-sited RIs and foundations, the denomination turns out to be 'council' in most cases, while it can be 'general assembly', 'council', or 'assembly of members' for ERICs and other consortia.

The primary duties of the Director or members of the Board of Directors should be to support the General Assembly, manage day-to-day operations, follow the directions and decisions made by the General Assembly, as well as provide

[4] http://roadmap2018.esfri.eu/strategy-report/the-esfri-research-infrastructures-list/.

feedback from other boards and committees, implements the Annual Work Plans and prepare their own internal procedures for organisation and meetings. This body represents the actual management body, which has fewer tasks than the management body of private companies. Often this body is also referred to as 'executive body', but the fact of being 'executive' does not preclude strategic management and coordination activities. According to Laurent Romary (then chairman of the Board of Directors of DARIAH), the director general is not an executive of DARIAH-ERIC. The most executive part of his work is entrusted to an efficient coordinator office[5] that supports the board. The fact of being executive or not must be defined in the statutes or bylaws and, therefore, may depend on the RI (Romary, 2017).

The same analysis of the ESFRI landscape shows that most of the RIs use the denomination 'director general' for the management body (this denomination is evident in some ERICs but especially for IGOs), while in other cases 'director' or 'Board of Directors' is used. Only a few RIs analysed use names such as 'executive board', 'management board', and 'executive director'.

There are also other committees that may be relevant and assist the RIs in economic governance. One is a scientific advisory board, which is a technical body that provides consultancy. Its focus is on the mission of the RI, making sure it performs to the highest standards (Baines, 2017). It plays a significant role in providing strategic scientific advice to the RI Board. Its most important duties are to review applications for new nodes and make recommendations to the Board, ensure scientific and technical excellence and relevance, provide useful feedback, know-how, experience, ideas, and advice to develop research activities according to the latest challenges and trends, and report directly to the Board of Directors on the results of their scientific review of activities. Other committees or bodies that help manage the particularities of RIs have different names and tasks, such as the finance committee, the industry committee, the risk management director, the safety environment and health physics director, and the supervisory board (see details in Table 2).

Given the enormous disparity in terms of mission and vision, organisational structure, costs and benefits, and the type and multidimensionality of stakeholders (scientific, technological, economic, public, or policymakers), it is interesting to examine the key differences between RIs and private companies in terms of governance structure.

In private companies, the assembly has functions similar to those in RIs, namely approving financial reports, electing and removing members of the Board of Directors, and amending the statutes. In contrast, in the case of the Board of Directors/Director, the body of private companies seems to have more power, especially with regard to the task of 'governing the organization by establishing broad policies and setting out strategic objectives'. In private companies, the strategic objectives are the responsibility of the Board of Directors, while in RIs, it is more complicated to assign this task to a specific and univocal body.

[5]The National Coordinator Committee shall be one of the two operational organs of DARIAH ERIC. Its aim is to integrate and coordinate national DARIAH activities at the European level.

Table 2 Other RI committees

RI	Legal model	Names of other bodies
BBMRI	ERIC	Finance Committee, Steering Committee, Central Executive Management Office, Stakeholder Forum, Common Services (ELSI, IT, others)
CERN	IGO	Finance Committee
CESDA	ERIC	Main Office (trust support, technical, training, project working group); Service Providers Forum
DARIAH	ERIC	National Coordinators Committee, Joint Research Committee
DESY	Foundation	Desy Photon Science Committee, Physics Research Committee, Machine Advisory Committee, Scientific Committee
E. SPALLATION SOURCE	ERIC	In Kind Review Committee; Technical Advisory Committee; Administrative and Finance Committee
EATRIS	ERIC	Board of National Directors
ECCSEL	ERIC	RI coordinator Committee, Ethics and Environmental Advisory Board, other advisory committee
ECRIN	ERIC	Steering Committee
EIBIR	LLC	Industry Panel
ELI	Association	Executive Committee
ELIXIR	Consortium	Industry Advisory Committee
EMBL	IGO	Finance Committee
EMSO	ERIC	Executive Committee
ESA	IGO	Administrative and Finance Committee, Industrial Policy Committee, International Relations Committee, Security Committee, Science Programme Committee
ESO	IGO	Finance Committee, Scientific Technical Committee, Observing Programmes Committee, Users Committee
ESRF	LLC	Machine Advisory Committee
ESS ERIC	ERIC	Methods Advisory Board, Finance Committee, Core Scientific Team
ICOS	ERIC	Head Office, Carbon Portal, ICOS RI Committee
ILL	IGO	Subcommittee on Administrative Questions, Director's Services (safety environment and health physics, medical service, risk management, public relations, industrial liaison unit)
JIVE	ERIC	Head Office, Technical Operations and R&D, User Support
LIFEWATCH ERIC	ERIC	The Standing Committee, The Financial Committee, The Ethics committee
PRACE	Association	Industrial Advisory Committee, Access Committee
SHARE	ERIC	Questionnaire Committee

Certainly, one of the most challenging problems that arise in decision-making at RIs is the relationship between the decision-making body, or assembly, and the executive body, specifically the Board of Directors. The right to vote is a fundamental tool in exercising decision-making power. Therefore, it is essential to determine the most effective way to distribute voting rights in each RI. In general, it appears that RIs choose to give each member state a vote, and even if there are two representatives per country, the two usually vote as one. Another problem related to this is the extent to which a member state can contribute, particularly in terms of financial resources. Even in this case, the contribution often depends on the defined calculation basis, which is usually GDP. In such a case, wealthier countries contribute more financially but have the same voting power, which is often a cause for discussion.

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