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Measuring the integration and coordination dynamics of the European Research Area

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This paper is concerned with the reconfiguration of national research and innovation (R&I) systems towards a European Research Area (ERA). We conceptualise R&I activities as either: integrated at European level, coordinated with other European partners or nationally juxtaposed. Such a conceptualisation can be usefully applied to the measurement of progress towards the ERA along the lines of: providing orientation for R&I, programming and funding of R&I, and performing R&I. Based on a newly constructed set of indicators, and using purpose-collected budgetary data from major pan-European R&D initiatives and other R&D statistics, we apply this framework empirically to the process of Europeanisation of publicly funded R&I. Our estimates show that Europeanisation of R&I has increased substantially over the past ten years. Europe has entered a new phase of Europeanisation of R&I, a phase that opens up the opportunity to achieve a further intensification of Europeanised R&I.

Keywords: R&D funding indicators; European policy; innovation systems.

1. Introduction

Since the formulation of the goal to realise the ERA in the year 2000, we have seen an intense debate about the objectives, the process and the means to achieve it. The ERA concept re-invigorated the debate about the Europeanisation of research which had been rather latent in the preceeding years. It culminated in the ERA Vision 2020 document which outlined the medium-term perspectives for the future of research in Europe (Council of European Union 2008).

However, the debate about Europeanisation is not new, not even with respect to R&D. Much academic and policy thinking was done during the early years of the EU when the fundamental goal of Europeanisation as such was still heavily contested. The EURATOM treaty and the creation of the Joint Research Centre (JRC) in 1957 provide evidence of the significance of research in those early debates. The establishment of the Framework Programmes for Research and Technology Development (FPs) in the early 1980s was another important milestone. These two examples mirror the fundamental tension in this debate, with the JRC standing for an integrated and centralised model of research performance, and the FPs representing a coordinated and decentralised model of research performance, both being funded through a centralised re-distribution mechanism.

One of the crucial challenges in the context of the Europeanisation debate is how to capture the process of change by way of meaningful analysis and measurement.

This, in turn, presupposes a good conceptual understanding of different types of Europeanisation models against which to compare progress. Both conceptualisation and measurement are essential for monitoring progress towards 'the ERA', and thus for the ability to steer the process of Europeanisation in a transparent and evidence-based manner.

It is against this background that we aim to contribute to a better understanding of integration and coordination in research as the two basic modes for describing the dynamics of Europeanisation, as well as to the development of better measurement approaches for tracing this process.

More specifically, the main objective is of a conceptual and methodological nature: namely to propose a novel methodology for measuring the dynamics of Europeanisation in research. Thus, this paper also has an empirical element in that it revisits the quantitative knowledge about the Europeanisation of research accumulated during the past 20 years by applying a rigorous indicator-based methodology.

The paper is structured as follows. Starting with a review of the theoretical and empirical literature on the emergence of a European research system (Section 2), we propose a two-dimensional conceptual framework of how the Europeanisation of research can actually be mapped (Section 3). It builds on the dichotomy between integration and coordination as the two basic modes of Europeanisation of research, and the simple juxtaposition of national research. We then examine the changes towards Europeanisation of the main functions relating to the governance of the research system: the orientation, programming, funding and research performance functions. This framework is then used to trace in a qualitative way the evolution of research in Europe since the 1950s (Section 4). Ultimately, it serves as a background for the formulation and application of the new quantitative approach to measuring the Europeanisation of research (Section 5), which is applied using data for the past ten years (Section 6). For this quantitative analysis, we concentrate on the programming, funding and research performance functions in order to simplify the data collection. We conclude with some remarks on the trends in Europeanisation in terms of its different modes and on the implications this raises for the monitoring of future evolution of the ERA (Section 7).

2. Europeanisation in R&I: A review of the literature

Until recently, the research focus in Europeanisation studies was on the political and economic integration of the EU but not much on the dynamics of integration in R&I which has attracted the attention of scholars only lately. A central issue in that literature is the supposed evolution of Europe from a collection of more or less self-contained national R&I systems to the composite, which one may justifiably term the European research and innovation system (ERIS). The realisation of an ERA represents a specific configuration of how such a ERIS could be realised.

Evidence provided from the analysis of bibliometrics suggests that collaborative links between researchers within Europe are growing and doing so at a greater pace than with the rest of the world (Mattson et al. 2008). Moreover, and consistent with the view of integration, the distribution of intra-European collaborative links is becoming increasingly diversified over time (Frenken 2002; Okubo and Zitt 2004). A number of studies report evidence of an increasing European 'systemness', along with a decrease in the importance of national borders, at least to a certain extent (Frenken and Leydersdorff 2004; Horta and Veloso 2007; Tijssen 2008; Hoekman et al. 2010; Paier and Scherngell 2011; Scherngell and Lata 2012).

However, the existing literature does not report evidence of major structural changes in the relationships between member states which are consistent with a complete integration process (Tijssen 2008; Hoekman et al. 2009; Hoekman et al. 2010). Rather, the consensus seems to be that, by and large, national borders still matter a great deal. This general finding should not come as a surprise: European political and financial initiatives to promote the development of ERA started less than ten years ago, and the history of the European FPs only started in the early 1980s. Institutional and structural changes are long-term processes and thus longer periods of analysis than the 1990s and beginning of the 2000s would be needed to reveal their true dynamics.

Some studies have looked at the integration processes at policy and institutional levels as well as at the coherence of the supra-national structure, including the identification of its actors, and have attempted to verify whether or not shared values and institutions are present. The major question for studies from a political institutionalist perspective is whether a new 'European' system is emerging and what its stage of development is. In this stream of literature, the nature of the integrative activities is often distinguished by their degree of formality: the formal ones are inscribed in treaties or directives, and the informal are derived from 'spontaneous' interactions and collaboration at the level of research activities.

More than ten years ago, and thus well before the definition of the political concept of ERA, Gergersen and Johnson (1996), using the national innovation systems approach as analytical framework, concluded that the European research system is in an emergent phase. Based on institutional learning processes as part of integration, they have identified the morphology of the European research system in the making as a 'system of systems'. The proposed structure contains a supra-national layer, composed of the European institutional arrangements and set-up, and a top layer comprising all the diverse European national innovation systems. This structure is

similar to the one described implicitly by Caracostas and Soete (1997) which highlighted the relevance of post-national organisations formalised in treaties, built within or outside of the EU, as well as European institutions and rules.

Other recent studies find no conclusive evidence so far that a European 'system' has already been achieved at the institutional level either, but showcase some evidence that there is one in the making, although so far without an established morphology. Edler and Kuhlmann (2005) studied the formation of the European research system through the analysis of the impact of the new funding instruments in FP6 and other trans-national institutional initiatives, both EU and non-EU on the institutional landscape. This provides, at the least, evidence of the shift of the programming function towards the European level. They argue that there a multi-level governance framework is emerging for R&I policies in Europe.

Borrás (2004), approaching the topic from a sociological and institutional economics perspective, goes a step further in her assessment of the state of advancement of an ERIS. She argues that the European system is in formation based on three dimensions of institutional 'systemness': *ethos*, *telos* and *geo*. She considers that although the *ethos* (European common values) is already clearly identifiable, the *telos* (the purpose) is yet in a state of flux, however, in the specific case of the ERA, it is attaining a federal nature (final aim for the ERA), and the *geo* (the boundaries) also remain unclear. In her opinion there is already a European way of managing uncertainty and risk in society, and a formal European institutional system set-up. However, she agrees that the ERIS has not yet been achieved because no consolidation or alignment of the informal institutions at the European level could be found. Neither is there a clear delineation of the geographical and institutional boundaries of the system.

Luukkonen and Nedeva (2010) elaborate on the cognitive and social aspects of integration at the level of European research communities and research performing organisations, which include structural and organisational developments, as opposed to 'fragmentation'. The empirical case studied measures the integration of a research community driven by a European policy instrument to promote excellence. The results show that previously dispersed national knowledge communities have increased their European integrative levels. However, the corresponding metrics do not yet allow for comparisons in a robust manner. Rightly, their concept of integration focuses on the formation of a new entity from different parts, either with a permanent or transitory nature, through endured relationships, shared interests, and alignment of norms and procedures. This concept of integration differs, however, from our definition of the relationships in Europeanisation developed later in this paper as the option of coordination as an alternative concept of Europeanisation is disregarded.

So far, public expenditures have scarcely been used to measure the evolution of the relationships that are occurring at the pan-European level in the different programmes and organisations, despite their suitability to capture activities related to the programming function in particular. The only exceptions are the European Commission's Science and Technology Indicators reports (European Commission 2003), published regularly since the early 1990s, and the recent Science, Technology and Competitiveness (or 'key figures') reports (European Commission 2009, 2011). Although not explicitly concerned with Europeanisation processes, these reports compare the amount of public funding that is: nationally distributed, coordinated at pan-European level through mechanisms such as EUREKA[1] or the European Cooperation in Scientific and Technical Resources (COST), or distributed to inter-governmental organisations or through the EU. We expand along these lines to offer a conceptual framework that characterises the evolving relationships between European member states in the context of the ERA and provide additional empirical evidence on the 'Europeanisation' of programming and research performance functions.

3. Conceptual framework

3.1 Theoretical context

A growing stream of literature dating back to the late 1980s emphasises the systemic nature of innovation. This is a rich and diverse body of theoretical work drawing from evolutionary economics which is exemplified in policy-oriented work on 'innovation systems'. Approaches to the study of innovation systems typically stress the importance of institutions and proximity for shaping innovation processes and associated interactions, but differ primarily with respect to their respective delineation of the system's boundaries (e.g. a country, region, sector or technology). The first to be developed was based on national boundaries, and then followed by regional, sectoral, or technological levels.[2] This paper draws from this stream of literature and examines the evolving relationships between national R&I systems in order to address the issue of their 'Europeanisation'.

A national innovation system is conceptually defined as a set of processes of production, diffusion and use of knowledge through interactions and relationships of actors, including the governance of the system and the institutional and social arrangements that characterise a nation state (Freeman 1987; Lundvall 1988; Nelson 1993). The key elements of a system are therefore knowledge infrastructures, the knowledge-producing and -using actors and their networks as well as the institutional framework within which they operate. The latter includes policies, regulatory frameworks and culture. National borders signal institutional, political, linguistic and

cultural fault lines: they define both what is 'inside' a system and what lies 'outside' of it. Almost by definition then, national borders act as barriers to knowledge flows.

More recently, the insights gained from these actor-centred perspectives on innovation systems have been generalised by formulating a set of key 'functions', or purposeful activities, that an efficient and effective system needs to perform. One stream of literature identifies seven functions, ranging from the mobilisation of the resources required to stimulate innovation development, down to the creation of new knowledge and to market formation (Bergek et al. 2008; Hekkert et al. 2007), whereas others have recourse to slightly different definitions (Chaminade and Edquist 2010). Naturally, the specific functions defined by various authors can differ due to their analytical perspective and to the varied institutional configurations encountered in the empirical settings.

Here, we use another conceptualisation i.e. on a theoretical level, we refer to the principal–agent theory as applied to science policy: the basic question is to understand how non-scientists get scientists (agents) to do what citizens, represented by the public authorities (principal), have decided (Guston 1996). The principal is the actor who disposes of a number of resources but not all those needed to achieve its objectives, lacking capacities, skills and information. It therefore delegates its task along with resources to an intermediary agent (e.g. funding agencies), who will be responsible for the implementation. The standard principal–agent relationship is thus refined by adding a third, intermediary layer of organisation.

It is important to note that such a configuration does not mean a hierarchical relationship between the principal and the agent, the latter having an informational advantage over the former. The relationship is a 'two-way street', each side having a certain degree of autonomy.

In the case of science policy, such a 'tryadic configuration' between government, research councils and scientists has been put forward (Braun 1993; Rip 1994; Braun and Guston 2003), formulated in terms of research councils as intermediate bodies which institutionalise the relationship between the government as principal and the scientists as agents. In this perspective the government acts as principal to the research councils and the research council as principal to the scientists, which defines two 'two-way relationships' (Rip and Van der Meulen 1996). The model is one where the research council—as an intermediary institution, would be both an agent, in the relation to the government—and a principal, in relation to the scientists (Van der Meulen 2003). This model has been used, for instance, to analyse and discuss the configuration of research policy institutions (Van der Meulen 2003; Slipersaeter et al. 2007).

A similar representation has been proposed for research systems. This approach goes beyond the traditional principal–agent thinking by assigning 'functions' to each of the three levels. It considers the government as being primarily in charge of the 'orientation function', the intermediary institutions (research councils) as in charge of the 'programming function' and the scientists in charge of the 'research performance' function (Barré 2008).

Thus, there is a double delegation relationship: first, between the public authorities and the intermediary organisations; and secondly, between the intermediary organisations and the research actors, which defines three macro-functions, as proposed by Barré (2008):

- *Orientation function:* This is undertaken by political authorities. It involves elaborating a vision of the future of the system and defining its institutions and overall objectives, as well as establishing its governance and budget. Moreover, it comprises the definition of overarching objectives and rationales for prioritisation in programming and funding, legitimised by referring to societal benefits that should be reaped and by arguing a defendable case for government intervention.
- *Programming (and funding) function:* This function is performed by organisations, such as funding agencies, 'intermediary organisations' which mediate between science and the state (Rip and Van der Meulen 1996; Braun 1998). Their purpose is to endow research actors with the necessary resources to conduct research, but it is also to steer the development of knowledge in areas that are considered priorities for public policy (Arvanitis et al. 1986), as defined by the orientation function. This function thus involves translating the objectives of the former into the specific scientific priorities and implementing the processes of funding to allocate resources to the research performers, at institutional, research group or individual level.
- *Research performance function:* This is undertaken by research performers (e.g. public research organisations, universities and companies). It involves: the employment of researchers, operating the research infrastructures, managing research projects, the diffusion of knowledge, the interaction with the other actors, as well as building up and maintaining networks of collaboration and researcher mobility. In order to realise this function properly, a delicate balance needs to be struck between the high degree of autonomy for scientists, which is essential for stimulating creativity and generating new knowledge on the one hand, and the thematic and organisational guidance needed to cohere with the orientation and programming objectives on the other.

In short, each macro-function deals with the problem of resource allocation for research in its own way:

- by providing orientations on the purpose of the research
- by setting up programmes and implementing instruments to finance research according to the above purposes

- by exploiting the resources made available to perform research

It should be noted that the focus of this interpretation is on public funding, including funding that is directed towards private firms.

Here, we move a step further by generalising the tryadic principal–agent model in two ways:

- We loosen the tight link between function and organisation. In particular, we extend the notion of intermediate organisations in charge of the programming function beyond research councils, which can be performed either by a specific organisation, such as a research council, but also from within an organisation which may also have another function, such as a public research organisation.
- We use the model to represent the multi-level structure of research systems, extending it to the European (and regional) set-up of research policy. This is crucial for the purpose of our paper because it allows us to explore different configurations of how functions are distributed between the respective organisations at European, national and regional levels.

In order to operationalise this framework in a multi-level system such as the one in Europe, it is necessary to provide a transparent assignment of specific functional activities to each of the three levels. Each level of governance (European, national, regional), involves all three functions and can be described accordingly:

- *At European level:* The orientation function is undertaken by the European 'institutional triangle' composed of the European Parliament, the European Council (in particular the Competitiveness Council) and the European Commission (in particular the Commissioner for Research, Innovation and Science); the programming function is mostly borne by the Directorate General (DG) Research and Innovation (and some other DGs with minor responsibilities for R&I), and the performance function by the JRC but also by all the public and private research organisations which benefit from funding from the European budget.
- *At national level:* The orientation function is undertaken by the national government (in particular the ministers in charge of research, higher education and innovation) and the national parliament; the programming function is undertaken by the national research funding organisation (research councils or agencies, national programmes managing organisations etc.); the performance function is undertaken by the public and private research organisations, including higher education organisations, which receive funding from the national budget.
- *At regional level:* The situation differs from country to country, being almost non-existent in some; the orientation function is undertaken by the elected regional authorities (regional council) and their executive arm; the programming function is undertaken by the regional services (regional funding council) and the performance function is undertaken by the entities benefiting from the regional research funds.

Research in Europe can thus be described as three sets of organisations: one set of organisations dealing with the orientation function, a second set with the programming function and a third one with research performance—each set covering the European, national and regional levels.

As a next step against the background of our conceptual framework, we need to define, characterise and measure the evolution towards the 'Europeanisation' of the R&I systems of the various regions and nations of Europe.

3.2 Completing and using the model to define the Europeanisation of research

In order to characterise the Europeanisation of the research systems, drawing upon Barré and Gaillard (2009), we define three types of possible relationships between the organisations of the national or regional levels concerned with a specific function, i.e. within each set mentioned above. The organisations of the regional or national levels can have, in the context of each function, relationships of:

- *Integration:* This is a concept that has been object of a wide body of literature mostly developed by political scientists. Some definitions have been put forwarded in research policies equating it to social dynamics and processes of institutional change. While Luukkonen and Nedeva (2010) and Luukkonen et al. (2006) define integration in research activity as the outcome of a social process and political process promoted through coordination and collaboration, which might lead to a *de novo* entity or to a composite entity composed with the original components but aligned;[3] Gregersen and Johnson (1996) and Borras (2004) equated integration to a process of institutional change in the dynamics of Europeanisation.

In line with the above, we refer to integration as the full delegation of the decision and action (of the orientation, programming or performance functions) to one entity with considerable autonomy and independence, even though national (or regional) representatives participate in its governing bodies. Such an entity is usually an organisation with a legal status, but can also result from contractual arrangement among existing (national or regional) entities.

- *Coordination:* This is the process through which aims and practices of the national (or regional) entities (of the orientation, programming or performance

functions) are jointly defined and constructed creating a common understanding and a shared culture, through common guidelines and assessment. In this case the national (or regional) entities remain, decide and act with independence, but their decisions and actions are bounded and shaped by the voluntary recognition of a common framework of reference.

In contrast to integration, the ultimate decision-making power on important budgetary and major content-related matters remains at national level, even if coordination processes between countries and/or regions are being established to prepare these decisions. The Open Method of Coordination that encompasses common guidelines, periodic monitoring and reviews, adopted by the European Commission in 2000 with the approval of the Lisbon agenda, provides a good illustration of the coordination concept.

- *Juxtaposition:* Juxtapositioning of the orientation, programming or performance functions is based on the existence of independent co-existing decision-making processes focused on the autonomous development of entities and organisations, either ignoring each other or in competition with each other. In this case, the decisions of entities and their outcomes are neither integrated nor coordinated: they are juxtaposed.

While the identification of a juxtaposed relationship is usually straightforward, the distinction between the two relationships that characterise different types of Europeanisation processes (i.e. coordination or integration) is anything but simple since most real situations are positioned in a continuum between the two. Following a review of past work and keeping in mind the task at hand, we propose three criteria to distinguish integration from coordination:

- *Single locus of the decision-making process:* The decision-making is delegated to a single (integrated) body. Even if the nationally based actors actively participate in the decision-making process (e.g. voting rights or consensus building), they do so as participants in a single decision-making process.
- *Single budget:* The resources devoted to R&D are placed in a common pool, implying that, from there onwards, there will be a common decision-making process.
- *Strong institutionalisation:* A strong structural dependency is built (Peterson 1991), among which, for example, international treaties meaning that membership can for all practical purposes be considered to be irreversible.

This leads to a completion of our conceptual framework which allows a definition and characterisation of the 'Europeanisation' of R&I systems in Europe. It can be presented in the form of a matrix, crossing the types of relationships (R) between the entities or organisations and the functions (F) of the system, i.e. the relationships × functions (RF) matrix (see Tables 1 and 2).

For each function (A, B and C), we consider all entities or organisations in Europe, of European, national or regional level; for each. We define if the corresponding budget is handled (for the orientation, programming or performance function) in an integrated, coordinated or juxtaposed manner (index 1, 2 and 3) at the European scale.

For each function (line of the matrix) the total public R&D funding is distributed among its relationships types: each function has a profile in terms of the relative importance of its relationship types.

We call Europeanisation the increase of the relative (budgetary) weight of the columns in Table 1 referring to the integration and coordination types of relationships.[4] This definition enriches the notion of Europeanisation on three grounds:[5]

- Coordination is considered as a possible form of Europeanisation, complementary to the restrictive vision of integration as the only Europeanisation modality.
- Europeanisation is addressed in a more specific way, distinguishing the situation of the three functions, which may have different Europeanisation dynamics.
- Beyond the dynamics of nations, Europeanisation also refers to the dynamics of regions, which are accounted for in the framework.

Table 1. RF matrix: a conceptual framework

Functions	Relationships			
	Europeanisation		3. Juxtaposition	TOT R&D*
	1. Integration	2. Coordination		
A. Orientation	A1	A2	A3	TOT A*
B. Programming and funding	B1	B2	B3	TOT B*
C. Research performance	C1	C2	C3	TOT C**

*Total of public funding of R&D from sources based in Europe.
**Total of publicly funded performance.

Table 2. RF matrix: specification of meaning of each cell

Functions	Relationships		
	Europeanisation		
	1. Integration	2. Coordination	3. Juxtaposition
A. Orientation	A1. EU level political decisions and budgetary processes: institutional triangle of: European Council, European Parliament and European Commission	A2. Policy design and budgeting by governments on their own resources: done in a coordinated way, i.e. in a single policy perspective, with or without European Commission intervention. Example: governmental level of the Grand Challenges/joint programming policy conception and overall budgeting; inter-governmental research organisations strategic orientations elaboration	A3. National research budgets and research policy elaboration processes by national parliaments and governments (same at regional level)
B. Programming and funding	B1. Integrated programme design, thematic priorities definition and funding from a common or single budget (pot). Example: FP thematic programmes set-up and implementation; programming activities in some inter-governmental research organisations	B2. Joint programming, with or without EU funding, but national funding reserved to own participants, including *juste retour*. Example: programming activities of joint technology initiatives, ESA, EUREKA, ERANETs, joint programming initiatives	B3. Nationally based programming and funding. Example: activities of national funding agencies or research councils, except what is in B2
C. Research performance	C1. Research performance of EU or inter-governmental institutions. Example: JRC, CERN, EMBL	C2. Research performed in a binding institutional contractual arrangement among several national organisations: consortium agreements or strategic alliances. Example: FP projects consortia in 'coordinated actions'	C3. Research performed in national organisations, except what is under C2. Example: Public research organisations activities within their own budget

4. Europeanisation in historical perspective: An overview

Section 4 aims to examine the history of Europeanisation of R&D over the last half century through the lens of our conceptual framework. In doing so, this section serves to empirically support the claim that the distinction between integration, coordination and juxtaposition is meaningful and can be usefully applied to chart the evolution of ERIS. Specifically, we assess the major initiatives in European R&D in terms of the changes in the relative importance of both the three different relationships (integration, coordination and juxtaposition) and functions (orientation, programming, performance) (see Table 1). In doing so, we uncover the shifting weight of integration versus coordination over time as well as the changing focus of what is integrated (e.g. a relative decrease in the integration mode of the performance function).

4.1.1 From the mid-1950s to the late 1970s: Europeanisation as integration of programming and of performance functions in restricted areas. In this period, Europeanisation meant the creation of large international research infrastructures related to the 'big science' areas. This was mainly implemented through two types of procedures:

- The inter-governmental way, consisting of international treaties among interested government setting up an international organisation having an (integrated) performance capacity. An example is the European Organization for Nuclear Research (CERN), created in 1954. It is characterised by having decision-making and budget control within the organisation's boundaries, while simultaneously ensuring the collective participation of member states (Hermann et al. 1987). The model has since been replicated in other research and technological topics exhibiting the same type of characteristics, e.g. the European Molecular Biology Laboratory (EMBL) in molecular biology.
- The 'Community' way, i.e. the initiatives taken in the frame of the treaties creating the European Communities (now the EU). Provisions for research were made in two out of the three founding treaties of the EU, the Treaty of Rome and the EURATOM Treaty. In essence, these treaties are the creation of an integrated orientation function for research, which is still valid today. At the time, they also focused on integrating the performance function in specific areas through the creation of the Joint Nuclear Research Centre (today the JRC), according to Article 8 of the EURATOM Treaty.[6]

From the application of our criteria for the identification of integration coordination and juxtaposition dynamics, it can be assumed that in the first case, both programming and performance functions are integrated (while orientation is

coordinated), while in the second, all three functions are integrated among member states.

However, in spite of early initiatives and successes, virtually no new inter-governmental research organisation was created after the 1970s, the exception being the International Thermonuclear Experimental Reactor (ITER) (which has partners beyond the EU).

In that period, national entities, in the three functions, were essentially not concerned by those initiatives: Europeanisation was indeed confined to specific—and limited—areas of research ('big science'), where integration was complete or almost complete. The rest of research remains in a juxtaposed situation.[7]

4.1.2 From the late 1970s to 2000: Europeanisation as coordination of national entities and their performance function through European funding. From the 1980s onwards, the change of focus from big science to generic technologies (i.e. information technologies, new materials or biotechnology) shifted the requirements for the organisation of research, to collaboration (coordination) rather than co-location (integration) (Rothwell and Dodgson 1992).

This is the period of the creation (1984) and development of the European FP which aims to address the requirements of generic technologies and to enhance overall European competitiveness. The key characteristics of the FPs are that:

- Their budget is essentially allocated to research performing organisations within the countries.
- The research must be performed in collaboration by those organisations through consortia.
- There must be co-funding between the European Commission and the organisation, thus involving national funds.

Applying our criteria, the performance function is no longer simply integrated by European budgets: instead, they also coordinate national performing entities (in consortia for research projects) and some national funding outside the European budget—namely the matching funds required for FP projects. The orientation and programming functions for the European research budget remain integrated (the European political process on the one side, the FP programming and managing processes on the other). Interestingly, an important inter-governmental initiative of this period, the EUREKA programme, devoted to funding closer-to-the-market research, is built on the same coordination configuration.

A third noteworthy initiative of this period is the R&I component of the regional European structural funds (SFs) created in the early 1990s when the initial SF scheme[8] was reformed. Since about 2000, SFs have been supposed to place more emphasis on the funding of R&I infrastructures. Following our criteria, SFs keep the orientation function integrated at the European level, but the programming function is coordinated between the European Commission and each concerned member state, and performance is carried out at a purely national context—it is juxtaposed.

In this second period, coordination in programming and performance functions added a new dynamic relationship to Europeanisation in addition to the integrative and juxtaposed types of relationships. Collaboration of research performers at the European level increased with the development of the FPs and other jointly designed European initiatives such as EUREKA. However, European funding remains integrated for the orientation and programming functions.[9]

4.1.3 Since 2000: Europeanisation as fostering coordination of national entities involved in the orientation and programming functions: Beyond FP projects (the building of the ERA). Since 2000 with the launch of the ERA and the parallel Lisbon strategy (European Commission 2000), a new rationale for Europeanisation emerged, namely the coordination of national budgets in the orientation and programming functions, with the FP providing instruments and incentives for that overarching objective. The adoption of the Open Method of Coordination (for the orientation function), and the implementation of new instruments such as the ERA-NETs, the European Strategy Forum for Research Infrastructure (ESFRI) scheme and the Technology Platforms (for the programming function) are examples of that. The move towards joint programming in 2008 represents one of the most recent initiatives in this perspective (European Commission 2008).

This third stage refers to yet another extension of the Europeanisation where national research budgets, in their orientation and programming functions, are voluntarily coordinated among the member states, even in cases where the funding of projects (performance) by the European Commission is minimal and even non-existent. The important issue is that the volume (level) of Europeanisation is no more—or much less—constrained by the volume of the European research budget as it was mainly in the first two periods (more than 90% of the cost of research is linked to the performance function). The frontier of Europeanisation is no longer that of the size of the EU research budget. Rather, it is the political will of the member states.

5. Methodology for compiling the RF matrix

The historical excursion in Section 4 gave a first impression of the interpretative power of our framework. However, our aspiration is to operationalise the framework in a more concise way in order to measure Europeanisation in

quantitative terms. For this purpose, we must assign quantitative budgetary values to each cell of the RF matrix, i.e. position each and every budget for public research in Europe which is funded by European, national and regional sources within that matrix.

5.1 Overall rationale: The policy instrument as the building block of the matrix

Each element of the public budget for research has a specific type of relationship regarding the three functions, since every unit of resources (or budget) is processed from the stage of being voted by a parliament or elected body (regional, national or European orientation) to being prioritised and channelled (programming) and spent in a research activity (performance). Each budget appears once, in a specific type of relationship, in each line of Table 1.

The question now is to identify the relevant 'unit of budget' or building block for assessing the type of relationship for each function, i.e. enabling us to fill the RF matrix. It appears that the notion of 'policy instrument', understood in a broad sense, fills the criteria: has a given profile of types of relationships over the three functions. For practical reasons, it is relevant to focus on the instruments of Europeanisation (addressing basically columns 1 and 2 of the RF matrix (see Table 1)) and fill column 3 of that matrix (the 'juxtaposed' budgets column) as the difference between the (known) total public budget and the sum of columns 1 and 2.

In practice, we included the following Europeanisation instruments (see detailed description in Appendix 1):

- in the EU budget:
  - the FP, broken down into a few instruments which differ regarding their programming and/or performance status
  - the SFs
- in the national budgets:
  - the participation of formalised inter-governmental research organisations, broken down with regard to their programming and/or performance status
  - the participation in inter-governmental programmes or networking activities

As we have seen, other parts of the national research budgets are 'Europeanised', namely the national 'matching funds' linked to the above instruments, distinguishing between 'project matching funds' and 'programmes matching funds', which differ in their programming function status. Then, for each policy instruments we characterise their profile (type of relationship) on the three functions, which allows us to identify their position in terms of the cells of the RF matrix (see Table 3).

Finally, having the budget for each building block, we can dispatch them to the relevant cells of the RF matrix. To obtain the final RF matrix, we sum up the budgets of the building blocks within each cell.

5.2. Data sources and computation of the budgets referring to the building blocks (see Appendix 2)

In contrast to traditional methodologies, we approach the Europeanisation measurement problem by identifying major policy instruments and then apportioning the funding referred to those instruments, to one of the three categories (juxtaposition, coordination, integration), in the context of the three functions. Such an approach has empirical difficulties, which we will discuss in this section.

5.2.1 The scope of the data gathering. Our definition of 'Europe' is not restricted to the 27 member states comprising the EU. 'European' here refers not just to EU bodies and their initiatives but to any initiative with a trans-national orientation based in Europe. We aimed for an annual time series beginning in 1980, considering all instruments that were in existence at that time. In the end, data was only sufficiently complete for 1999–2008 and we therefore restrict our analysis to that period.[10]

5.2.2 Data regarding EU funding and inter-governmental organisations, programmes and activities. In identifying the European instruments which are relevant to our study we consulted the Science, Technology and Competitiveness key figures report 2008/2009 (European Commission 2009: 103) and the ERAWATCH inventory of European support measures and organisations (ERAWATCH 2010).

Sourcing the budgetary data needed has been a challenging task (see Appendix 2 for sources). Despite our best efforts to obtain such information by sourcing annual reports and by way of direct correspondence, large gaps persist in the budgetary series, especially for inter-governmental research organisations, some of which we addressed with empirically derived imputations.[11] Imputations were also used to construct a time series of COST budgets.[12] Single missing year observations were estimated as the average of the preceding and the following year.

Moreover, for many instruments, budget data is not available by year, but is allocated for long programming periods (e.g. FP7 2007–2013). Given that it is the decision to allocate the funds over the programming period that is of political importance, an equal distribution over time seems reasonable.[13] Therefore, the time series for those instruments was reconstructed by dividing the total for the period by the number of years.

In estimating the public funding of EUREKA we followed previous practice (European Commission 2008: 68), in assuming that 50% of the total budget comes from public sources. Figures coming from annual accounts (such as those from inter-governmental research

Table 3. Policy instruments and their profile on three functions: position of building blocks in RF matrix

Functions Instruments (building blocks of RF matrix)			A Orientation	B Programming	C. Research performance
Framework Programme	JRC		A1	B1	C1
	Thematic programmes	EC funds	A1	B1	C2
		National (matching) funds [project matching funds*]	A3	B1	C2
	ERANETS and EUROCORES	EC funds	A1	B2	C2
		National (matching) funds [programmes matching funds]	A2	B2	C2
	JTI + Art.169	EC funds	A1	B2	C2
		National (matching) funds [programmes matching funds]	A2	B2	C2
	ERC + Marie Curie	EC funds	A1	B1	C3
Structural Funds		EC funds	A1	B2	C3
		National (matching) funds	A2	B2	C3
Inter-governmental research organisations	Research performing organisation/infrastructure	CERN, EMBL, ESO	A2	B1	C1
	Funding body	ESA	A2	B1	20% C1 80% C3
Inter-governmental programmes or activities		Eureka, COST	A2	B2	C2
Other public funding for research (national and regional)			A3	B3	C3
Total			Total public R&D funds	Total public R&D funds	Total public R&D funds

All EU funding (FPs and SFs) is by definition A1 (EU institutional triangle); it is usually B1 except for JTI or ERANET which have B2; it is seldom C1 (just JRC), often C2 (FP programmes consortia) and seldom C3 (ERC, Marie Curie grants). For SFs it is B3 and C3.
National matching funds are by definition A3 [for some large JTI and SFs it can be argued there is A2, i.e. governmental level direct budgetary discussion/negotiation with the EC of the national funding], B3 for project matching funds and B2 for programmes matching funds; they are C2 or C3 depending on specific cases.
Inter-governmental organisations are by definition A2 and B1; if they are a research organisation or large infrastructure, then it is C1; in the case of ESA, for performance, we assume 20% as C1 (estimated part of intramural R&D) and 80% as C3 (estimated part of subcontracted R&D).
Inter-governmental European programmes or activities such as EUREKA and COST are A2, B2, C2.
For 'other public funding of research (national and regional)': it is the national research budget (GBAORD) minus all elements of this national budget which are either integrated or coordinated (Europeanised); it is important to recall that EU budget is outside national budgets, but that funding of inter-governmental organisations, programmes and activities relate to national budgets.

organisations) and budgets for instruments with long programming periods (such as the SFs) correspond to expenditures but, due to lack of any other information, the same figures have also been used in programming.

5.2.3 The national funds leveraged by the European instruments (matching funds). The major difficulty is that systematic and comparable information on the Europeanisation (whether through integration or coordination) of national public funding for R&D is lacking. The necessary data elements are not collected regularly and have no clear antecedent in statistical practice. Standard statistical methodologies[14] for counting government budget appropriations for R&D and government R&D expenditures are very much nationally minded and lack the complementary information needed to fit them into the RF matrix. Formal data generating and collection mechanisms for such data are still at a nascent stage.[15] Thus, we had to compute the Europeanised parts of the national budget through proxies based on EU budgets (matching funds).

The FP and the SFs are based on the principle of co-funding project costs with national sources. For the FP, we first identified the extent of activities where the co-funding principle was applicable (typically FP Thematic Funding, i.e. without human resources, ERA instruments and JRC/EURATOM) and then calculated national funding assuming a 50% contribution from the member states. We assumed that two-thirds of the national contributions to FP projects come from public sources.[16] For the SFs,[17] we split the totals into funding allocated to (what were for the most part) Cohesion (Objective 1) countries (Greece, Portugal, Ireland, Spain for 1999–2006; Greece, Portugal and new member states afterwards) and non-Cohesion countries.[18] For the former we assume national co-funding to the tune of 30%, while for the latter we assume 50%.[19]

5.2.4 Units of measurement: Currency and time—discounting problems. Another challenge for the construction of indicators that are comparable internationally, over time and over type is to ensure that the figures are expressed in a common unit of measurement. Inter-governmental research organisations budgetary information is denominated in currencies other than Euros. Historical exchange rates between the Euro (ECU prior to 1999) and other currencies were obtained from the European

Commission's DG Budget,[20] annualised and then used to convert figures dating back to 1999. As no historical conversion rates are available for the period prior to 1994, the conversion series average was used instead.

The use of purchasing power parities was considered but deemed irrelevant as:

- We are not making cross-country comparisons, but comparing a single entity (the EU) over time.
- We are not concerned with the impact of R&D (= purchasing power) but with the political act of its commitment and expenditure.

Likewise the use of deflators is not warranted, as we are only interested in proportional changes and inflation would impact equally upon both sides of the fraction.

5.2.5 Overall assessment of the data collection. In addition to the above provisos, and despite our best efforts, the underlying data, and by extension the resulting indicators, suffer from the following limitations. We cannot be certain that our inventory of Europeanised R&D budgets is exhaustive. Specifically, we could find no systematic information on bilateral or multi-lateral R&D initiatives between European countries that fall outside the scope of the major instruments. Our indicator estimates assume that these are not large enough to have a major impact on European-level trends.[21] It is also possible that such agreements are generally *ad hoc*, driven by issues of bilateral importance, and as such cannot be taken as suggestive of long-term political intentions with respect to European integration. Moreover, where estimation choices had to be made (e.g. on imputations), we chose to err on the side of caution, choosing conservative assumptions. These omissions mean that our estimates may understate the true magnitude of the activities that our indicators of Europeanisation intend to proxy.

In total, we estimated that our data collection can provide significant results in terms of ascertaining orders of magnitude and major trends.

6. Results and discussion

To measure the integration and coordination dynamics of the ERA we will use the following indicators, defined with the notions of Table 1 (see Box 1).

6.1. The RF matrix

Having identified the budget of each instrument (in the sense of Table 3), allocated them to the cells according to Table 3 and added them within each cell we obtain the RF matrix, computed for year 2000 (mean of years 1999–2001) and for year 2007 (mean of years 2006–8) (see Table 4)

Considering that the indicators about the orientation function would not add much to our argument as it is made at this stage, while making the presentation more complex, we leave them out of the computation and of the results.

6.2. Main results

Based on the definition of indicators as provided in Box 1, we obtain a set of key indicators (see Tables 5–7). Table 5 confronts key indicators of integration and of coordination for both programming and performance functions in order to show how quickly the coordination mode in programming and programming has grown as compared to the integration mode.

In 2000, overall, integration is more developed than coordination (7.0% against 6.4%) and coordination refers mostly to performance (through research consortia in the FP for a good part). In 2007, the level of integration has not changed, while coordination has almost doubled (from 6.4% to 12.5%), becoming more developed than integration (12.5% against 7.1%); this rise of coordination is mostly due the very strong increase of coordination in programming (from 3.9% to 14.1%, which is a multiplication by 3.6).

Table 6 focuses on indicators of Europeanisation (understood as the addition of the integration and coordination modes), distinguishing the contribution of the two functions of programming and performance. Overall, Europeanisation has increased by half (13.3% to 19.6%) in the period 2000–7. The Europeanisation of programming has evolved from a contribution hardly larger than that of performance (54–46) to a position where it represents almost 2/3 of Europeanisation (64–36), becoming the driving function of Europeanisation.

Finally, Table 7 looks at the relative contribution to Europeanisation of programming (as compared to performance) and of coordination (as compared to integration). Both programming and coordination have changed from contributing to half of the Europeanisation to contributing to two-thirds of it. In other words, in 2000 Europeanisation was based equally on programming and performance on the one side, and on coordination and integration on the other. In 2007, for Europeanisation, programming is twice as important as performance and coordination is twice as important as integration. It can be said that today, Europeanisation is fundamentally based on the coordination of the programming function.

The indicators show a double shift in the period 2000–7: from integration to coordination and, within coordination, from coordination of performance to coordination of programming.

6.3. Interpretation and discussion

Linking to the historical discussion (see Section 4), the evolution of the Europeanisation of research can be described as follows: in the post-World War II period

Box 1. Definitions of indicators

Indicators of integration

- Index of integration of programming function:

  $\mathrm{INT[PROGR]} = (\mathrm{B1}/\mathrm{TOTB}) \times 100$

  percentage of programming function which is integrated

- Index of integration of performance function:

  $\mathrm{INT[PERF]} = (\mathrm{C1}/\mathrm{TOTC}) \times 100$

  percentage of performance function which is integrated

- Index of overall integration

  $\mathrm{INT[TOT]} = (\mathrm{INT[PROGR]}+\mathrm{INT[PERF]})/2$

  mean of percentages of integration of programming and performance functions

Indicators of coordination

- Index of coordination of programming function:

  $\mathrm{COORD[PROGR]} = (\mathrm{B2}/\mathrm{TOTB}) \times 100$

  percentage of programming function which is coordinated

- Index of coordination of performance function:

  $\mathrm{COORD[PERF]} = (\mathrm{C2}/\mathrm{TOTC}) \times 100$

  percentage of performance function which is coordinated

- Index of overall coordination

  $\mathrm{COORD[TOT]} = (\mathrm{COORD[PROGR]}+\mathrm{COORD[PERF]})/2$

  mean of percentages of coordination of programming and performance functions

Indicators of Europeanisation:

- Index of Europeanisation of programming function:

  $\mathrm{E[PROGR]} = [(\mathrm{B1}+\mathrm{B2})/\mathrm{TOTB}] \times 100$

  percentage of programming function which is Europeanised (integrated or coordinated)

- Index of Europeanisation of performance function:

  $\mathrm{E[PERF]} = [(\mathrm{C1}+\mathrm{C2})/\mathrm{TOTC}] \times 100$

  percentage of performance function which is Europeanised (integrated or coordinated)

- Index of overall Europeanisation:

  $\mathrm{E[TOT]} = (\mathrm{E[PROGR]}+\mathrm{E[PERF]})/2$

  mean of Europeanisation index of both functions

Indicators of modalities of Europeanisation

- Index of Europeanisation through programming function:

  $\mathrm{MOD(E[PROGR])} = (\mathrm{E[PROGR]}/2\mathrm{E[TOT]}) \times 100$

  percentage of overall Europeanisation due to Europeanisation of programming function

- Index of Europeanisation through coordination:

  $\mathrm{MOD(E[COORD])} = (\mathrm{B2}/\mathrm{TOTB}+\mathrm{C2}/\mathrm{TOTC})/2\mathrm{E[TOT]} \times 100$

  percentage of overall Europeanisation due to coordination type of relationships

Table 4. RF matrix for years 2000 and 2007

Relationships Functions	Europeanisation		3. Juxtaposition	TOT R&D
	1. Integration	2. Coordination		
Year 2000, in current billion €				
B. Programming and funding	7.86	2.93	64.84	75.63*
C. Research performance	2.15	5.45	54.16	61.76**
Year 2007, in current billion €				
B. Programming and funding	12.09	15.28	81.09	108.46*
C. Research performance	2.49	9.00	71.17	82.66**

*Public funding (= GBAORD + international initiatives not normally included in GBAORD).
**Publicly funded execution (= publicly funded GERD + any international initiatives not included in GERD).

Table 5. Indicators of integration and coordination (in % of total public R&D)

	Indicators of integration			Indicators of coordination		
	Programming	Performance	Overall	Programming	Performance	Overall
2000	10.4	3.5	7.0	3.9	8.8	6.4
2007	11.1	3.0	7.1	14.1	10.9	12.5

The overall value of programming and performance is their mean; the overall value of integration and coordination is their sum.

Table 6. Indicators of Europeanisation

	Indicators of Europeanisation		
	Programming	Performance	Overall
2000	14.3	12.3	13.3
2007	25.2	13.9	19.6
Contribution 2000	54	46	100
Contribution 2007	64	36	100

Table 7. Indicators of modalities of Europeanisation

	Indicators of modalities of Europeanisation Contribution of:	
	Programming	Coordination
2000	54	48
2007	64	65

until the late 1970s, Europeanisation of research meant sharing integrated big science infrastructures dealing with both programming and performance of research and being of relatively small size in comparison to the research systems as a whole—hence relatively low levels of Europeanisation, equally concerning programming and performance, coordination being almost absent.

In the 1980s and 1990s, while the big science organisations of the previous period—which were mostly intergovernmental organisations—developed at only moderate pace and without expanding to new areas, the FP became the new arm of Europeanisation. It allowed the flourishing of research consortia—which means coordination—among research performance organisations throughout Europe. In 2000 the index of coordination for the performance function became higher than its index of integration (8.8% against 3.5%). At the same time, SFs applied to research (mostly research infrastructures) developed. This leads to coordination in programming, which shows through the take-off of the corresponding index, at a modest 3.9% since this funding scheme was limited to the less developed regions.

In 2000, Europeanisation reached the level of about 15%, balanced between the programming and performance functions, the integration mode still being more important than the coordination one (7.0% against 6.4%). This level of Europeanisation in this model reaches a limit since: big science integrated infrastructures no longer constitute a priority, and coordination is focused on the performance function (8.8% against 3.9% for the programming function) through FP consortia, whose overall volume was limited by the size of the FP.

After 2000 with the launch of the ERA and the FP6 ERA-dedicated instruments another model of Europeanisation has emerged as a superposition of the two previous

models (big science integrated infrastructures and performance coordination through the FP)—completed by a whole new scheme, namely coordination of the programming function. This latter feature has more than tripled in volume in seven years (from 3.9% to 14.1%), becoming the most important of the four pillars of Europeanisation (the others being the two related to integration and the coordination of the performance function). In this new model, Europeanisation is mainly based on the programming function (64% of the value of the index of Europeanisation against 36% for the performance function) and on the coordination mode (65% of the value of the index of Europeanisation against 35% for the integration mode).

This is the expression of the ERA vision, where Europeanisation is no longer limited by the volume of the FP,[22] its limit being the political will of the member states.

7. Conclusions

In this paper, we have proposed an enriched definition of the Europeanisation of research, considering that it should be assessed along the major functions of the research systems and along various types of relationships among member states.

We have also proposed indicators to measure those dimensions of Europeanisation and we have—albeit partially—computed them at two dates. The interpretation of those indicators has enabled us to revisit the history of the Europeanisation of research of the last six decades. We have shown that three main phases of development can be distinguished and that the most recent phase is not only characterised by the growing importance of Europeanised functions, but also by the emergence of a new mode of Europeanisation that is driven by coordination in programming and funding. While it does not supersede the previously dominant mode of integration, coordination now represents the most significant contribution to Europeanisation: a contribution that is likely to grow further as it is not limited by the willingness of member states to transfer resources and competencies to Brussels, but can respond to the full range of nationally funded research activities.

In methodological terms, the framework developed and the data compiled represent a first step and a basis for a refined approach to the monitoring of the process of moving towards an ERA. The next challenges are to complete the indicators:

- by including those relative to the orientation functions
- by explicitly including the funding by the regions
- by computing values for year 1980 and possibly earlier
- by developing national indicators of Europeanisation
- by developing sectoral/thematic indicators of Europeanisation

Finally, we suggest that the elaboration and vision building for the ERA and the Innovation Union could make use of such definition of Europeanisation with its associated indicators: strategic foresight could thus benefit from quantitative guideposts which make both historical and political sense.

In the longer term, it would be interesting to explore what benefits have resulted from the creation of an ERA by comparing Europeanisation indicators and output indicators of the emerging ERIS with corresponding data from the USA, Japan and China. The results of such a comparison may be difficult to interpret because we neither know how Europe's (relative) performance would have evolved if the steps towards Europeanisation had not been taken, nor can we isolate the effects of integration processes of the respective R&I systems in the USA, Japan and China on their respective output performance, but it would nevertheless be interesting to compare the long-term dynamics of integration/coordination and R&I performance.

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Notes

1. EUREKA is a pan-European organization that aims to coordinate funding efforts of governments, research institutes and commercial companies concerning innovation.
2. Further developments have defined the innovation systems in different geographical boundaries. Regional innovation systems (Cooke 1996) consider regions to be the most appropriate unit as shared of culture and interactions are very much dependent on proximity. Using the same reasoning but different construals of proximity, sectoral or technological systems of innovation have also been proposed, considering industrial sectors or the technologies as the shared

space (Carlsson and Stankiewics 1991; Breschi and Malerba 1997; Markard and Truffer 2008).

3. Luukkonen and Nedeva (2010) assume integration to be the process of forming strong, persistent relationships through social and cognitive processes. Our framework is complementary to theirs in the sense that we focus more on the social and organisational aspects, as well as on policy-driven processes; hence our concern with governance, and our identification of the orientation, programming, funding and research performance macro-functions. Moreover, we also consider the option of coordination as an alternative mode of Europeanisation.
4. In quantitative terms, this means a relative increase of A1 + A2 and/or of B1 + B2 and/or C1 + C2 as a percentage of the total public R&D budget (TOT).
5. Although in the quantitative part below we will have to set aside the computation relative to the orientation function and to the regional budgets.
6. Although coordinated actions were also foreseen in the treaties, as indirect interventions to support activities promoted by member states, they were mainly implemented after the 1980s when the first multi-annual FP was launched.
7. This is why Banchoff (2002) argues that inter-governmentalism is a mechanism developed by European countries in order to keep untouched their national sovereignties, preventing the move towards a more federal Europe. While inter-governmentalism has not led to greater concentration of power at any single 'federal' chamber, it has certainly contributed to strong and hardly reversible structural dependencies that are qualitatively very distinct from the mere voluntary coordination of national R&D resources.
8. Council Regulation (EEC) No 4254/88 of 19 December 1988, laying down provisions for implementing Regulation (EEC) No 2052/88 as regards the European Regional Development Fund, in the *Official Journal of the European Communities* dated 31 December 1988, No L 374, pp. 15–20.
9. The SFs, in which programming is coordinated, are an exception in this respect, but refer to a policy rationale which is not primarily a R&I policy one.
10. However, insofar as some budgets during the period 1999–2008 are simply projections on the basis of observed trends from before 1999, we are including here a discussion of methodological issues relating to this earlier period.
11. Missing observations were imputed using each organisation's average annual growth rate (derived from a period for which data was available) to reconstruct the trend. Figures for the following inter-gevernment research organisations were thus imputed (observed rate, period concerned): European Centre for Medium-range Weather Forecasts (ECMWF) (4.5%, 1992–2004); European Incoherent Scatter (EISCAT) (3%, 2006–9); European Molecular Biology Laboratory (EMBL) (6%, 1980–2003); European Molecular Biology Organization (EMBO) (5%, 1980–99).
12. The decentralised nature of COST Actions makes the calculation of precise budgetary figures especially difficult. Figures for 1999–2003 are estimates provided by the COST mid-term review, while figures for 2004–2008 are from ESF Annual Reports. Figures for prior years have been estimated from the number of new COST Actions, following the widely assumed average Action budget of €400,000 (i.e. €100,000 per annum, assuming an average Action duration of four years as suggested by Grabert (2010) and COST (2010), and as also indicated in the COST the mid-term review (Horvat et al. 2010).
13. Arguably, though for the performance function, a more precise accounting of annual variation could be important, as expenditures tend to concentrate in the middle years of a programming period. While we experimented with the imposition of some bell-shaped distribution (i.e. for the FP and the SF applying retrospectively annual distributions known from the latest programming periods), in the end we settled for a simpler equal annual distribution to avoid the introduction of artefacts and ensure consistency between instruments.
14. Developed by the OECD and documented in the Frascati manuals (latest: OECD 2002).
15. The JOREP project, led by Emanuela Reale, Centro Nazionale di Ricerca (CNR), and funded by the European Commission, is preparing a methodology for such data collection, in linkage with Eurostat and national statistical offices. It focuses on research funding programmes distributing project funding to research groups—which are a sub-set of what we are considering here. It defines 'joint' programmes as the sharing of one or more of the 'functions' involved in programming (i.e. programme design, evaluation of proposals, funding decisions and management of financial contributions), This model and methodology are compatible and complementary to ours. So far, no publications are available.
16. This seems a reasonable assumption, in the light of the fact that private (for profit) organisations account for about one-third of all FP7 participations (Parliamentary Office of Science and Technology 2010: 2).
17. Figures for the period 1999–2009 are expenditures, whereas for 2007–13 they are commitments.
18. In relevant European treaties and in EU policy discussions 'cohesion' refers to the strategic objective to reduce income disparities between countries and regions in the European Union. Cohesion countries were the countries given preferential access to the EU's Structural Funds due to their relatively low income per capita. Objective 1 regions/countries are those with a per capita gross domestic product lower

than 75% of the Community average. The mentioned countries are compose of a combination of regions that meet the objective 1 criteria (i.e. they are lagging behind) and others that are converging towards the average.

19. This seems reasonable in the light of the bounds stipulated by Article 29, paragraph 3 of European Council (1999), Council Regulation (EC) No 1260/1999 of 21 June 1999, *Official Journal of the European Communities*, L 161/1 (in force during the period under consideration).
20. See <http://ec.europa.eu/budget/inforeuro/index.cfm?Language=en> accessed 7 July 2010.
21. These account for less than 1% of total national Government Budget Appropriations or Outlays on R&D (GBAORD), according to the first data collection of Eurostat on GBAORD devoted to transnationally coordinated research (European Commission 2011: 243).
22. The incentives for coordination in programming correspond to very small amount of funding as compared to the cost of research projects.

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Appendix 1

Table A.1. Europeanisation instruments included

Instrument	Description
Framework Programme (FP)	Major research policy instrument of EU, includes direct funding of research teams, researchers (ERC, Marie Curie), EURATOM (and F4E), European Commission's JRC as well as co-funding for a host of 'ERA instruments'
In which we distinguish:	
ERA-NETs, ERANETS+	ERANETs are networking platforms intended to facilitate European coordination of national and regional research policies and mutual opening up of national and regional research programmes. Distinction between integrated (common pool) and coordinated funds
JTIs - Art. 171 (Lisbon Treaty Art. 187)	Joint Technology Initiatives (JTIs) are long-term public–private partnerships for large-scale multinational R&D in areas of major interest to European industrial competitiveness and issues of high societal relevance. Partly FP-funded. The following JTIs were included: JTIIM, Artemis, CSI, ENIAC, FCH
Art. 169 (Lisbon Treaty Art. 185)	Article 169 (LT 185) enables EU participation in research programmes undertaken jointly by several member states, including participation in structures created for execution of national programmes. Partly FP-funded
EUROCORES	EUROCORES (European Collaborative Research) Scheme is a framework for collaborative research in topics benefiting from or requiring pan-European collaboration. Partly FP-funded
Structural Funds (SF)	Part of the EU's Regional and Cohesion funds, substantial (and increasing) portions of which are devoted to R&D and innovation
Inter-governmental organizations (institutionalised)	The following intergovernmental research organisations are included: Kopernikus (Global Monitoring for Environment and Security-GMES) ESRF (European Synchrotron Radiation Facility) GBIF (Global Biodiversity Information Facility) EFDA (European Fusion Development Agreement) ECMWF (European Centre for Medium-Range Weather Forecasts) CERN (European Organization of Nuclear Research) EISCAT (European Incoherent Scatter) EMBL (European Molecular Biology Laboratory) EMBO (European Molecular Biology Organization) ESA (European Space Agency) ESO (European Organisation for Astronomical Research in the Southern Hemisphere) EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) NordForsk (Nordic Research Board) EPPO (European and Mediterranean Plant Protection Organization) EMBC (European Molecular Biology Conference) ILL (Institut Laue-Langevin)
EUREKA	Europe-wide market-oriented industrial R&D and innovation initiative
COST	COST (European Cooperation in Scientific and Technical Research), is an Inter-governmental framework targeting à la carte R&D cooperation at level of research of teams and institutions. Its membership includes 36 states, from EU and neighbouring countries

Appendix 2

Table A.2. Data sources

Instrument	Geographic coverage	Latest annual budget (year)	Source
Framework Programme (FP)	ERA	€8,483 m (2012, excl. co-funding of coordination instruments)	European Commission DG Research Technology and Development (RTD) (various sources), annual reports (F4E),
Structural Funds (SF)	EU	€8,287 (2012)	Disaggregation of SF into types of activity produced at JRC-IPTS in context of RHOMOLO model (Regional Holistic Model), using data from the European Commission's internal database (operated by Directorate-General for Regional Policy), and following methodology proposed by Varga and Veld (2010)
ERA-NETs	ERA	€119 m (2009)	Metrics study
ERA-NETs+	ERA	€28 m (2010)	ERA-NET + Review report
Inter-governmental organisations	Variable membership (majority European)	€5,230 m (2008)	Annual reports (CERN, ECMWF, EISCAT, ESA, ESO, ESRF, EUMETSAT, GBIF, ILL) Correspondence (EMBL, EMBO, NordForsk, EISCAT)
EUREKA (publicly financed)	ERA plus Russia	€659 m (2009)	Correspondence with EUREKA secretariat
COST	ERA	€24 (2008)	COST mid-term review, correspondence with COST secretariat and European Commission DG RTD
JTIs - Art. 171 (Lisbon Treaty Art. 187)	ERA	€462 m (2012)	CORDIS (2010), relevant JTI websites
Art. 169 (Lisbon Treaty Art. 185)	ERA	€208 m (2012)	CORDIS (2010)
EUROCORES	ERA	€15 m (2006)	COST and ESF annual reports
GBAORD	EU27	€87,604 m (2008)	RKF database (European Commission) based on integrated Eurostat/OECD data (accessed 9 June 2011)
Publicly funded GERD	EU27	€81,259 m (2008)	Eurostat NewCronos (accessed 13 April 2011)

ERA countries include all 27 EU member states, plus countries associated with FP (Albania, Croatia, FYR Macedonia, Iceland, Israel, Liechtenstein, Montenegro, Norway, Serbia, Switzerland and Turkey).