Coordination modes in public funding systems

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Abstract

The aim of this paper is to look to public research funding systems from the perspective of their broader institutional arrangements and of how these shape the relationships between funding agencies and research actors. Thus we consider public funding as a multilevel and multiactor system, where stable patterns are largely generated by the collective interaction between actors (beyond formal rules and structures) and where coordination between actors (especially funding agencies and performers) represent a key for the functionality of the systems. This drives us to propose a classification of the main organisational forms of public research funding in terms of their underlying coordination mode. Further, we develop the idea that national funding systems are composed by the combination of these basic arrangements and thus compatibility and complementarity between them are critical for the functioning of the system; this leads to identification of three ideal types of funding systems – the project-based model, the mixed model, the vertically integrated model - which seems to describe the variety of national systems and to a large extent underpin today’s’ discussion on European research policy.

1 Introduction

The aim of this paper is to look to public research funding systems from the perspective of their broader institutional arrangements and of how these shape the relationships between funding agencies and research actors. While funding systems have always been a central concern in research policy studies - a fact which can be hardly surprising given the distributive nature of this policy domain (Braun 2006) -, already a short review of the literature shows that they have been rarely addressed from this viewpoint (see however Benner and Sandström 2000 and Whitley 2003).

Broadly speaking, one can classify the studies in the field by distinguishing between those focusing on the policy and on funding agencies from one side and those addressing the choices and behaviour of research actors, at the level of individuals and research groups, as well as of whole research organisations. Thus, a number of studies have focused on the design of research policies and on how these impact on the mix of funding instruments (see Guston 2000; Larédo and Mustar 2001); comparative studies have also looked to similarities and differences between countries and spurred the debate on convergence of national research policies vs. the on-going relevance of national specificities (see among others Elzinga and Jamison 1999; Senker et al. 1999; Lemola 2002). More specific analyses have directly dealt with funding agencies and the portfolio of funding instruments, looking for example to the role and organisation of research councils (Braun 1998; van der Meulen 2003; Slipersaeter et al 2007) or overall to the composition of public project funding (Lepori et al. 2007). A rather distinct tradition has also been developed in higher education studies dealing with principles and approaches for funding higher education institutions (Jongbloed 2008).

At the recipients’ side, a very old tradition rooted in sociology of sciences and laboratory studies has focused on how the social organisation of sciences and its internal incentives drive the behaviour of individuals and the allocation of resources (Latour and Woolgar 1979), taking into account the role of reputation as the central asset in science (Merton 1973; Dasgupta and David 1994). Recent work looks to the impact of changing funding schemes towards more utility and politically-driven priorities and thus investigates the strategies of scientists for accommodating or shielding these changes (Laudel 2006), as well as their impacts on the working of science. Other studies have focused on the strategies developed by universities and public research organisations (PRO) to increase their funding basis and to respond to policy changes (Sanz-Menendez and Cruz-Castro 2003 for PRO; Jongbloed 2007 for higher education institutions).

Already this cursory view displays that most works in the field focused on a single system layer, looking to responses of individual actors and to horizontal relationships between them (for example cooperation vs. competition), but largely considering changes in other layers (for example at the policy level) as external factors, while there is a distinct lack of studies on interactions across institutional layers. The main exception has been the research line based on delegation and principal agent theory, investigating the relationship between state and the scientific community in terms of the characterization of general delegation modes (Braun and Guston 2003; Braun 2003) or dealing with specific vertical relationships between State, funding agencies and researchers (Caswill 2003; van der Meulen 1998). Yet in most of its applications, this approach tends to focus on the interaction between an individual agency and a set of researchers, overlooking the presence of multiple principals and the complex nature of network interactions between funding agencies, research groups and external stakeholders, for example in the case of research programmes (Shove 2003; Klerkx and Leeuwis 2003).
There are two further reasons why, despite its value, this approach seems to be less adequate to address the dynamics of today's research funding systems. Both of them drive to an increasingly distributed and multilevel nature of the system, which breaks with the traditional conception of state steering and top-down delegation implicitly assumed in most studies in the field (Morris 2003). The first reason is the multiplication of funding agencies and instruments (Lepori et al. 2007) and the emergence of the European and the regional levels as relevant for research funding; this drives to replace the idea of an overall policy rationale and coordination of public research funding with an approach based on a broad set of largely autonomous agencies and instruments. In this setting, soft coordination is ensured through mechanisms like the Open Method of Coordination (Borrás and Jacobson 2004), while mutual adaptation effects between the agencies themselves emerge (as witnessed with the creation of the European Research Council; see also the special issue of Science and Public Policy on limits of political coordination; Braun 2008). The second reason is the increasing role of performers organisations, both in the case of large universities (Bonaccorsi and Daraio 2007) and of large Public Research Organisations, which are becoming relevant actors also concerning funding allocation, largely as a consequence of new policy rationales granting them more autonomy. Performers assume a key role in linking the systems layers, since they are increasingly able to selectively mobilize their staff towards funding opportunities, but also directly interact with policy and funding agencies. Moreover, performers' internal allocation policies are highly relevant for strategic purposes and establish strong linkages between core funding to performers and project funding to groups and individuals, introducing a further feedback loop in the funding system (Jongbloed 2007).

In this context, this paper tries to provide some advances by focusing on a specific issue, namely looking to the macro-level structures of the funding system – the main blocks accounting for a large share of the total funding volumes – and the institutional arrangements which frame the actors relationships to generate stable (in the aggregate) and predictable behaviours and funding patterns. Further, I put forward some hypotheses on how these arrangements can be combined to derive macro-level models of the whole funding system. The paper is thus largely inspired by some recent work on the relevance of institutional arrangements for the working of science (Whitley 2003; Bonaccorsi 2007), but it applies specifically these concepts to research funding.

The following of the paper is organised in four sections. Firstly, I present a generic description of funding systems in terms of layers and allocation methods and I derive the relevant research questions to be addressed in the following. Secondly, I introduce the notion of coordination modes and interpret the main institutional arrangements of public research funding in terms of their underlying modes. Thirdly, I look how these modes can be combined together and I propose some basic models of funding systems based on the notion of institutional complementarities. The paper is concluded by a number of research avenues which might stem from the approach proposed here.

2 A framework on public research systems

To frame the analysis, figure 1 provides an overview of public research funding, distinguishing between four institutional layers – the policy layer, funding agencies, performing organisations and research groups/individual researchers, as well as between two main allocation methods, namely core funding to research organisations and project funding to research groups/individual researchers.
Figure 1. An overall view of public research systems

a) The identification of the layers builds on different traditions in science policy studies: the distinction in policy evaluation studies between the political level, where principles and strategies are defined, and the operational level of the agencies in charge of implementing policies; science policy studies looking to the central role of the intermediary level in sciences policies (Rip and van der Meulen 1998); finally, work on the triangular relationship between State, funding agencies and research in the principal-agent tradition (Braun and Guston 2003; van der Meulen 1998).

Of course, the notion of “Government” has become itself fragmented and multilayer with the emergence of the European Union as a relevant policy actor concerning research, but also with the increasing role of regional authorities (especially in federal states). Moreover, I use here the term agency in the broadest meaning, as all types of operational units in charge of allocating some portion of public funding, including also sectoral ministries and higher education funding agencies. While there is some understanding that these agencies are actors on their own (coherently with recent approaches on public administration; Braun and Gilardi 2006), their degree of autonomy (as well as of intermediation with the scientific community) can be highly variable from case to case.

The preceding discussion leads to the addition of a forth layer, namely performers organisations like universities or public research organisations, which constitute the organisational framework of research laboratories and groups.

It is important to notice that layers represent functions not organisational structures: even if in most cases they are organisational distinct, there are cases of organisations spanning across different layers, the most notable example being large PROs assuming some of the functions of a funding agency for their laboratories through internal evaluation and competitive allocation procedures (see Theves et al. 2007 for the French CNRS).

b) Comparative work on public funding systems has shown that most of them display a rather clear-cut distinction between core funding, allocated to performing organisations for their on-going activities, and project funding, attributed directly to a laboratory or an individual for well-defined research activities limited in time and scope (Millar and Senker 2000; Lepori et. al 2007). While there are large variations across countries in the share of the two methods, in the portfolio of instruments and the allocation rules, we identified very few borderline cases, like allocation of core funding through competitive proposals in the Czech Republic (Lepori et al. 2008), networks and centres of competences and the allocation of human resources to CNRS laboratories (Theves et al. 2007). There is thus evidence that this represents a basic structural distinction in research funding systems, which needs of explanation.

c) A growing body of literature shows that funding agencies, research organisations and research units should be conceived as semi-autonomous actors which are able to act strategically to reach their goals, exploiting the resources and opportunities provided by the environment (Oliver 1991; Rhodes, 1997). In this
context intelligence, there are no a priori hypotheses on which kind of actor drives the evolution of the system and could be considered as the principal in terms of the principal-agent framework (Braun and Guston 2003). In particular, I don’t believe that today’s highly differentiated funding systems follow a top-down logic, where the State defines policy goals and delegates tasks to funding agencies, while funding for specific types of research drives the behaviour of applicants. One could for example argue that, in reality, competition between laboratories takes place around critical resources – like highly reputed and creative people (Weisenburger and Mangematin 1995) – and once these have been purchased, research products or services can be pushed upstream to funding agencies (White 2002; Morris 2003). Or one could argue that the highly ranked PROs and universities drive also the allocation of project funding to individual teams through their institutional reputation and ability to attract the best researchers.

If looked at in this perspective, the main issue concerning research funding systems is not steering and delegation (Braun 2003), but rather coordination: to achieve system-level objectives – like production of new knowledge, economic and social welfare - strategies and choices of the different actors need some kind of matching, which in a distributed intelligence system cannot be achieved through policy coordination only. Thus, performers strategies to develop new research units need to be somewhat aligned with those of agencies providing funding for specific research, while agencies need to take into account the available capacities before launching new funding systems. At the same time, the strategies of research groups to develop their capacities need to collectively take into account the future orientation of research policy and availability of funding to avoid overcrowding in some areas and lack of competence in other areas. Further, actors’ decisions crucially depend on expectations on the future behaviour of other actors: for example, funding agencies have to make assumptions on existing research capacities, but also on the decision of performers to apply for their grants. Conversely, performers’ decisions on developing research capacity are largely built on expectations about future funding, but also about competition from other performers for the available schemes. The stability of these expectations is crucial for the functioning of the research system. Once a call has been launched the agency will be bound to distribute money among the received proposals and, if the applicants’ behaviour does not meet expectations, agency goals will not be reached. Conversely, if performers’ expectations on available funding are not met, investments on new research capacities might not produce the expected effects. This drives to consider that signalling and information exchange about future strategies and behaviour plays a central role in actors’ coordination (White 2002).

Thus, there are strong arguments, firstly, to expect that the system’s performance will crucially depend on the quality of coordination mechanisms between actors and, secondly, that, beyond individual interactions, stable institutional arrangements ensuring this coordination should have emerged in mature research funding systems.

3 Coordination modes and institutional arrangements

Actors’ coordination deals with the issue of how to organise collective action in a world where it is assumed that individual actors enjoy of considerable freedom of choice and can to some extent pursue their individual goals, while at the same time it cannot be assumed that self-interest will lead automatically to a social optimum through the market mechanism like in neoclassical economics. It is thus a widespread issue in economics, in political sciences and in sociology.

An emerging body of work in institutional theory has demonstrated the importance of institutions – i.e. systems of norms, values and beliefs accepted by the different actors – to constrain and shape individual choices and to produce regularities in the aggregate actors’ behaviour despite individual variance in individual choices and behaviours (Scott 2003). Of particular interest here are the approaches which focus on the (boundedly rational) individual actor as the elemental system component, while at the same time trying to understand how their embeddedness in institutional environments constrains and shape their behaviour to produce regularities and collective action, including neoinstitutional economics (Williamson 2000), rational choice theory in political sciences (Moe 1984) and agency theory in social sciences (Coleman 1990). Most of this work embraced an exogenous view of institutions – conceived as the set of explicit norms or rules limiting individual actor’s choices (North 1990). A broader view of institutions has been assumed by approaches like socio-economics (Holllingsworth 2002) and comparative institutional analysis (Aoki 2000) embracing the cognitive turn of neoinstitutional theories (Di Maggio and Powell 1991): they consider that institutions are to a large extent endogenous to the actors themselves and (collectively) shaped by their behaviour and thus that collective action can be sustained by a set of shared beliefs and actors relationships without being necessarily explicated in formal rules. These approaches open then the way to a much wider range of coordination arrangements beyond the classical dichotomy between markets and hierarchies (Williamson 1975); examples are clans for less formal organizations where cooperation is ensured through shared goals and beliefs (Ouchi 1980) or institutionalised markets (White 2002).

The issue of coordination can be looked at different analytical levels, including whole societies (at the level of nation state), industrial sectors (or organizational fields; Di Maggio and Powell 1983) of individual
organisations; then the issue is raised of the linkages and the compatibility between these levels, for example to which extent different forms of organisation of firms or of the whole business sector are compatible with wider societal values, for example contrasting European and East-Asian societies with their different values and social norms (Whitley 1992). When looking to the organisation of public funding systems, one is then be naturally led to assess the compatibility of the possible arrangements with the wider institutional environment, but also to ask which organizational forms at the level of performers and research groups can perform well in a given context.

At the level of social arrangements – covering whole societies or economic sectors -, a number of institutional arrangements have been distinguished based on their underlying coordination principle (Streeck and Schmitter 1985; van Waarden 2002; see Figure 2):

- **markets**, where coordination is handled through the set-up of prices and exchange contracts, which convey all the information required.
- **private hierarchies** (firms), where coordination is handled through internal rules systems and hierarchical authority.
- **clans or communities**, where coordination is based on a set of shared values and goals internalized by the community members.
- **public hierarchies** (State) coordinating through public rule systems, for example laws, as well as their control and enforcement (for example bureaucratic arrangements).
- **networks** of actors, based on semi-formal membership and rules, which rely on a mix of self-interest and social obligations, and **associations**, where memberships and rules are stronger formalised.

<table>
<thead>
<tr>
<th>Distribution of power</th>
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<tr>
<td><strong>Horizontal</strong></td>
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<td><strong>Self interest</strong></td>
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<td>1. Markets</td>
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<td><strong>Social obligation</strong></td>
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<td>2. Hierarchy</td>
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<td><strong>Social motive</strong></td>
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<td>3. Communities</td>
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<td><strong>Action motive</strong></td>
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<td>4. State</td>
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<tr>
<td><strong>Action motive</strong></td>
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<tr>
<td>5. Networks</td>
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**Figure 2. A taxonomy of institutional arrangements**

Modified from Hollingsworth 2002

The economic literature has widely explored the conditions for the functioning of these arrangements (Ouchi 1979). Thus, the market is seen as an efficient coordination mechanism, but at the condition that performance can be unambiguously measured; under these conditions, not only markets put very low information and control requirements, but also can tolerate a low level of socially shared rules and goals. Hierarchical structures are more robust against low ability to measure output, but require some understanding of the production technology, so that by controlling employees behaviour higher hierarchical echelons can reasonably control for the aggregate output of the organization; control costs can however be
high and limit the performance and the size of the organisation. Clans and communities can perform well where the transformation process is uncertain and outputs difficult to measure, but require a strong socialisation mechanism, especially to integrate in the community new entrants (Ouchi 1980).

In most cases, these mechanisms do not exist as alternatives, but combinations of them are effectively used to achieve good coordination: thus, economic markets for quality goods are based on a combination of social relationships and price (institutionalised markets; White 2002), while many formal organisational forms have emerged between hierarchical companies and communities, like private liabilities firms, associations, etc. (van Waarden 2002). Also, top-down public bureaucracies have been in many cases replaced by more flexible organisational structures through delegation to largely autonomous agencies (Braun 2006). While the selection of the coordination mechanism is to some extent related to the characteristics of the good and its production technology, the embeddedness of economic activities into wider social and cultural institutional environments can explain differences between countries in the organisational forms of economic activities (for example in firms’ organisation), a special focus for comparative institutional analysis (Whitley 1992) and socio-economics (Hollingsworth 2002).

In the real world, these (abstract) arrangements are embodied in specific combinations of norms, rules, organisational structures and actors’ configurations – like sets of funding agencies, funding instruments, allocation rules, etc. – , what I will call organisational forms of public research funding. If the hypothesis that coordination is a central issue for funding systems holds true, one would then expect that these forms can be classified on the basis of their underlying coordination mode; not only this would constitute the basis of a taxonomy of organisational forms of funding, but one could look to the general characteristics of coordination modes to explain to some extent the selection and functioning of funding schemes.

At first glance, one would argue that research is a typical case for communities and clans as the main institutional arrangements, because the measure of output is difficult, production technology is unclear and relationships between tasks and results ambiguous (Musselin 2007). It is easy to recognize here the ground for the long-standing tradition on academic communities and on academic reputation as the main mechanisms for the allocation of funding (Latour and Woolgar 1979). However, while these can be considered as the main coordination mechanisms at the micro-level (Whitley 2003), there are some arguments why more formal arrangements – including markets, public and private hierarchies – might be increasingly relevant at the system level. These include the multicultural nature of research policy, where academic culture and norms are faced to other public cultures like the administrative, the economic and social one (Elzinga and Jamison 1995); the distributed nature of the research funding system, with different actors having their own goals and norms (see for example differences among funding agencies; Slipersaeter et al. 2007); the rise of evaluative and managerial culture not only in public policies, but also in the working of large research organisations like universities (Whitley and Glaser 2008); finally, the sheer size of the system and the differentiation of policy rationales, funding instruments and research activities, which faces communitarian norms with strong limits in long-range coordination.

For these reasons, I will attempt to characterize public research funding at the scale of the whole system in terms of three prevailing coordination mechanisms, namely markets, private and public hierarchies. Moreover, I will argue that their functioning critically depends on their integration with two other arrangements, namely shared values and norms in communities and network arrangements.

### 3.1 Institutionalised markets: project funding

Project funding has been mostly examined in terms of delegation using principal-agent theory, to interpret the (bilateral) relationship between the state and research performers or the (trilateral) relationship between the state, intermediary agencies and performers (Braun and Guston 2003). However, the interaction between multiple agencies from one side and laboratories which are autonomous agents with their own strategies to the other side can be conceptualised in terms of the underlying coordination mode as a market (van der Meulen 2006), where funding agencies select the performer which best meets their goals, while performers themselves decide where to apply for funding and develop strategically their competences depending on the available sources of funds. We notice that competition takes place essentially concerning quality, while the price is in most cases more or less fixed; what research groups need to do is to decide if it is reasonably feasible to achieve the required level of quality and if its cost – for example for hiring people, developing infrastructures, writing a proposal - is worth the price that can be paid (depending on the other options available and on the perceived position of potential competitors).

From the agency perspective, there are well-known issues about choosing the best performer, given information asymmetry between agency and performers, as well as risks of shirking since, once the grant has been attributed, control becomes difficult and costly to implement (van der Meulen 1998). However, some framework conditions are likely to reduce these risks: high professional competences of specialised funding agencies, involving researchers themselves in their decision-making process, strong social ties and shared norms (for example the researcher’s ethos) and repeated and long terms interaction (the perspective
to get the next grant representing a strong incentive for the performers, while repeated interaction makes evaluation simpler).
From the performer’s perspective, the main issue is to be able to reasonably predict the level of quality required to get funded; this depends on stability and signals from funding agencies, but also of the ability of evaluating potential competitors and their future strategies, the literature suggesting that there are strong informational and cognitive limits to the number of player a quality market can accommodate (White and Eccles 1987).
From a system perspective, one can argue that project funding performs well under a moderate degree of competition: since usually the funding volume for each instrument is defined in advance, low competition means that funding agencies might have to finance also proposals which don’t match their goals and performers might find more convenient to submit proposals not fully matching agency goals. Conversely, high oversubscription rates not only increase implementation costs, but might imply that selection is increasingly based on past performance, thus reducing room for funding innovative proposals and taking risky decisions; since review of project proposals is an imprecise and contestable mechanism (Wood and Wessely, 2003), bidders might also be confronted to a very unpredictable situation (lottery effect) which doesn’t allow them developing a long-term strategy.
Thus, this organisational form is likely to function well for rather small-scale markets, where the number of players is limited, the type of research activities (the traded goods) is sufficiently homogeneous to allow for a reasonable and fair choice and, finally, there are strong social ties and shared values between players, either because they belong to the same community (like academicians) or the same geographical region. One can thus foresee a multiplication of funding instruments when the size of the system increases and the type of research services differentiates a phenomenon which is well documented in recent comparative work (Lepori et al. 2007). Conversely, one would expect that social ties and repeated interactions tend to identify a rather small circle of grant recipients with a reasonable success rate alongside a much larger circle of outliers, an hypothesis confirmed by some available data (Viner 2004).

3.2 Private hierarchies: core funding to HEI and PROs
A second organisational form of public funding is to rely on formal organisations to allocate funding to research groups, while the State limits its role to attributing a global budget to the whole organisation; we could consider that this organisational form relies on the combination between market coordination, with performer organisations competing among themselves for public resources, and private hierarchies for their internal organisation of activities.
There is evidence that this form is becoming more relevant for public research: thus, higher education institutions and public research organisations are increasingly considered as formal organisations, despite specificities related to the specific task of these organisations (Musselin 2007), while there is a tendency to formalise the relationships with the State through arms-length arrangements like performance contracts, evaluation practices and funding formulas based on output (Ferlie et al. 2008 for higher education; Bozeman and Crow 1990 for PROs).
From the perspective of the Government, this mode can be seen as a way of stronger steering the research system by building suitable incentive structures for the behaviour of forming organisations (Geuna 2001), avoiding delegation to (largely autonomous) funding agencies and the fragmentation of allocation channels; evidence from the UK, where this approach has been consequently introduced, shows that it has reinforced state steering and control on higher education institution (see Naidoo 2008). The monopolistic structure of funding leads then to stronger steering through market coordination than through bureaucracies.
The broad nature of higher education institutions, covering typically many scientific domains, entails however a number of limitations; either the State blindly delegates to the institutions themselves (just reimbursing a share of their costs) or can set broad incentives to steer the behaviour in some directions, for example using proxies of research output and its quality (either through formula allocation or including these criteria in performance contracts; Massy 2004; Jongbloed 2008). Decisions concerning research subjects, internal organisation and personnel management are delegated to the governing bodies of HEIs.
There are also limitations on the precision of allocation; metrics, like numbers of PhDs, publications, impact factors, aggregate the performance of whole institutions with all kind of methodological difficulties; it is thus understandable that most allocation strategies include both an historical and performance-based component (Jongbloed and Vosseseyn 2001). At the contrary, looking directly to the quality of individual research groups, for whole universities entails high implementation costs and the set-up of a monitoring structure with the required competences, as demonstrated by the UK research assessment exercise (Barker 2007) Also, using proposals to assess in detail research strategies of HEI is difficult given the complexity of proposals encompassing whole institutions and the difficulty of comparing proposals from different HEI. This might explain why the difference between core and project funding concerns at the same time the organisational level of funding and the allocation mechanism (the only relevant counterexample at my knowledge being competitive research plans of Czech universities; Lepori et al. 2008).
One can argue that the price paid for more centralised steering by the State is to provide a coarser allocation of funding to whole HEI and to lose control on the choice of research topics. Conversely, by aggregating funding one can reach more stability and predictability – most core funding schemes are designed to avoid strong fluctuations from year to year. Moreover, there are some arguments why higher education institutions should be better in place to develop and implement research strategies, including stronger institutional identification, shared values between direction and employees and, finally, smaller size and proximity.

3.3 Public hierarchies: vertically integrated public research organizations and branch PRO’s

The third distinctive form is to build top-down public organisations which allocate internally funding to their research groups, what we would consider as a public hierarchy in terms of coordination mode. The distinctive difference with the previous form relies on absence of (direct) competition between organisations, since it is assumed that the division of work (and corresponding allocation of resources) is decided at the political level. Looking to funding systems, two relevant cases can be identified, which can be distinguished by the different importance of community coordination.

The first case is the creation of a general-purpose public research organization channelling most of public funding in a specific domain. These organizations can be characterized as large public hierarchies, whose steering is delegated to representatives of the academic community (through committees internally elected and composed by academics) and where a strong identification with academic values is the basis of individual’s action. The French CNRS before the reforms of the last decades (Theves et al. 2007) and the Academy of Science in Eastern European countries are relevant examples of this arrangement; in both cases, they were supposed to manage the bulk of academic research, while higher education institutions were mainly devoted to education. In all these cases, membership to the community and internal careers, strictly controlled through entry selection mechanisms and peer evaluation, provided access to financial resources mostly through permanent employment status. The Polish case, where the same organisational form for public funding has been maintained, but replacing the Academy of Sciences with a ministry, shows that without a common (academic) culture this setting cannot work properly (Lepori et al. 2008).

This form – thanks to the combination between hierarchical organisation and academic competence in the steering committees – should allow a strong central planning of research capacities at the level of the whole system, concerning also the choice of the priority research areas, as well as coordination avoiding duplications of research areas. However, efficiency is bounded to the known limitations in the evaluation of the performance of the laboratories, since by design there will be limited competition on the same research subjects. Innovation at the organisational level, like creating new laboratories and opening new research areas, is also likely to be slow because of the length of planning cycles and of the limited freedom in resources allocation (mostly bound to permanent personnel); moreover, as the size of the organization grows, implementation costs – especially in time of the researchers involved in the decision-making committees – and the complexity of the decision-making process are likely to increase. The loss of importance of this model in most countries is likely to be related to changes in the organization of sciences, where new search regimes depend more on building complementarities than on concentration of efforts (Bonaccorsi 2008).

The second case are mission-oriented laboratories managed as branch offices of ministries producing directly the research services required to achieve policy goals (especially to support sectoral polices or to develop technology in specific domains). This bilateral relationship allows the principal to define in detail the goals and services to be delivered, for example through contractual arrangements and thus provides full control on research activities.

However, this form is confronted to the difficulties of hierarchical steering under incertitude and information asymmetry: while the research subject might be easier to control, the quality of performed research is more difficult without detailed assessment (requiring in the principal similar competences as the agent). Thus, one would predict that this mode can perform reasonably well for service activities and research which is directly of use by the principal for the implementation of its policies, but less for basic research. Comparative studies show that there is a strong tendency to grant a larger autonomy to these units through contractual arrangements, thus progressively shifting them to the previous form (PREST 2002; Bozeman and Crow 1990), but there are wide differences across countries in the extent of this process.

3.4 Associations, consortia and networks

While associations, consortia and networks are a widespread coordination mode of research activities, allowing to build more transient and light structures than formal organizations and to bridge different types of organisations – for example at the interface between universities and private companies -, what is at stake here is the use of these modes to allocate public research funding, what has been defined as network delegation (Braun 2003). In these schemes, the State attributes funding to a network or a consortium - with different types of rules and degrees of formalisation -, leaving to the internal decision-making process the allocation of funding between partners. Typical examples are a number of national of excellence schemes,
like the Swiss National Centre of Competence in Research (Braun and Benninghoff 2003) and the European Networks of Excellence (Luukkonen, Nedeva and Barré 2006).

There are some reasons why these models might be better able to coordinate research funding in specific areas than project funding agencies and research programmes. Thus, the decision to fund a network by a funding agency defines a closed partnership (possibly with some accession rules), limiting and structuring internal competition for funding; this in turn implies stronger identification and self-interest to act collectively and to strengthen the network itself; moreover, being collective structures, these organisational forms allow for stronger (personal and organisational) ties between funders and performers, than in funding agencies, where there is need for stronger distinction of roles to ensure a fair selection. The involvement of external stakeholders (users) in the decision-making process might be a further reason, as in the Dutch Bioconnect scheme (Klerkx and Leeuwis 2008). Involvement of users and performers makes networks a stronger coordination tool than research programs managed directly by funding agencies, where individual projects have a tendency to become independent and incentives to collaboration (once projects have been granted) are weak.

These features translate however in a number of limitations of these forms, which cannot be too large in terms of number of participants and of their funding volume and are closely dependent on changes in policies which might undermine the self-interest of their participants (for example creating competition on alternative funding sources); moreover, for equity reasons, it would be difficult to justify on a long-term basis a closed network distributing public funding and thus one can foresee a strong tendency to consider public support to them as transient, unless they evolve towards a funding agency model. However, networks can have wider effects if they lead to a durable structuring of the actors’ space which leverages also the allocation of project funding; at least for the European Networks of Excellence, this has been an explicit goal.

4 Looking for institutional complementarities

Table 1 summarizes the different coordination modes, how these are translated into specific forms of public funding and, finally, a view of their strengths and weaknesses emerging from the previous analysis.

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<thead>
<tr>
<th>Main Coordination modes</th>
<th>Public funding form</th>
<th>Strengths</th>
<th>Limitations</th>
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<tbody>
<tr>
<td>Market</td>
<td>Project funding</td>
<td>Tailored allocation of funding through review of individual proposals. Potentially an efficient allocation mode, targeting the best laboratories. Promotes competition and strategic behaviour of laboratories. Requires sufficiently small-scale markets and moderated competitive pressure, otherwise can become innovation averse. Institutionalised linkages between funding agencies and performers and some level of shared values also needed.</td>
<td></td>
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<tr>
<td>Market + private hierarchies</td>
<td>Core funding to higher education institutions and PROs</td>
<td>Allows direct State steering of organisational behaviour through incentives. Low implementation costs of allocation. High stability and predictability of funding. Shifts strategic decision-making to the organizational level. State loses control on research subjects and organization of research activities. Allocation is related to average quality of research teams, unless detailed assessment (with high implementation costs).</td>
<td></td>
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<tr>
<td>Public hierarchies + community</td>
<td>Vertically integrated PROs</td>
<td>Strong planning and coordination through public hierarchy and shared academic values. Concentration of resources in predefined fields. Innovation becomes difficult at the organisational level (while might be possible at the individual level). Control and measurement of performance are difficult. Implementation costs high especially if the organisation grows very large.</td>
<td></td>
</tr>
<tr>
<td>Public hierarchies</td>
<td>Core funding to public laboratories</td>
<td>Allows close steering and definition in detail of research services (when this is possible in advance). Control and measurement of performance are difficult, except for the more applied activities.</td>
<td></td>
</tr>
<tr>
<td>Network coordination</td>
<td>Centres of excellence and network schemes</td>
<td>Coordinate research strategies and funding acquisition strategies of different organizations. Build interfaces. Structure the performers space. Can hardly be adopted for managing the bulk of public funding for organisational and equity reasons. Difficult to maintain in this form over long periods of time. Risks of closed groups and exclusion of newcomers.</td>
<td></td>
</tr>
</tbody>
</table>
Table 1. Coordination modes and organisational forms of funding

However, already a cursory look to today's public funding systems shows that all of them rely on different combinations of the forms listed in table 1, while variations concern their role, share in the funding volume and how they are combined together in the whole system.

This leads to a well-known issue in institutional analysis known as institutional complementarities. Namely, a central argument supported by empirical observation is that in most cases no single institutional arrangements is likely to provide a suitable solution to the coordination problem of whole societal or production sectors: the strong case of institutional diversity is based on the observation that all institutional arrangements display some distinctive weaknesses, but also on the fact that too uniform institutional systems might provide not enough flexibility and dispose of a sufficiently rich repertoire of solutions to new issues and external pressures (Hollingsworth 2002). This is typically the case in social domains like technology and research where innovation is central for long-term performance.

If looked at in this perspective, the issue is not how to choose of the best mode of coordination, but how to develop institutional arrangements suitable to the characteristics of the production system for research, building on the complementarities and strengths of the different modes (Amable 2000). This can include the coexistence of arrangements ruling different part of the systems, like different research sectors, as well different funding streams for the same performers; but also combinations of different modes in original organizational forms, as well as building on the complementarities of modes through the coexistence of different funding channels. The hypothesis of complementarity assumes that among all possible combinations of institutional arrangements and coordination modes only some of them are well-performing and are more frequently encountered in reality (see Boyer 2005) and leads to an approach based on taxonomies of institutions arrangements, like varieties of capitalisms (Hall and Soskice 2000) and social systems of innovation and production (Amable, Barré and Boyer 1997).

Of course, funding arrangements, like all other sectoral institutional arrangements, do not exist in isolation, but are embedded in a wider political and institutional context (Hollingsworth 2002), a well-known issue also in research policy studies (Elzinga and Jamison 1995; Senker et al. 1999); compatibility with these long-lasting arrangements is thus likely to be a relevant selection criterion for the sector-specific arrangement. The imitation a master model, as promoted in many policy documents at the European and international level, should then leave its place to the assessment of which of the possible models can reasonably fit into a specific national context.

In the following, I propose three main models, namely the project-funding based model, the vertically integrated model and the mixed model. One should be aware that this is a heuristic exercise, based on evidence from the available comparative studies, but with no claim of being a rigorous taxonomy. Beyond their empirical validation, models are essentially normative representations of reality which drive actors’ choices and thus have a function even if they don’t fully match the reality. Today's political discourse seems to discount the vertically integrated model as a remnant of the past, while the debate on European research policy rests on divergent views on the choice between a project-funding and a mixed model (see Bonaccorsi 2007). The approach proposed in this paper could then be mobilised to design of other possible models (as well as an anticipation of their general properties) and thus to a more creative approach to policy choices on funding than just picking the best of the existing systems.

A final preliminary remark concerns dynamics and change. The approach proposed here focuses on the identification of possible models, considered as equilibrium situations, and thus it is largely static, a limitation shared by most works on taxonomies of institutional arrangements. Of course, like any other institutional arrangements, funding systems are the result of historical processes where a good deal of path-dependency is at work and are subject to continuous change, even if comparative work shows that key structural features are more lasting that it can be assumed (Lepori et al. 2007). Thus, one should carefully distinguish between the identification of general types and the analysis of the evolutionary trajectories of individual countries (even if the two should not be unrelated, if the identified models have some general value).

4.1 The project-funding based model

In this model, the State relies almost exclusively on project to allocate public funding. It distributes funding to a large number of agencies (including branch offices of ministries, research councils, technological agencies, etc.) which finance through competitive grants research corresponding to their organizational goals.

The state acts essentially as a buyer of research services; for each policy goal – including basic research, defence, health employment, environment, etc. –, there is a specific funding agency directly linked to the sectoral policy and closely integrated with it. Diversity of largely uncoordinated funding agencies is thus the rule and there is limited scope for overall coordination of research policy and of steering the research system itself. Of course, this model can leave room for a limited number of research activities directly funded by the State through contractual arrangements. One would foresee two typical cases, national facilities which are largely unique and public laboratories with a direct service to public bodies, where getting exactly the type of services required is a priority (for example in a regional context).
In institutional terms, this model assumes that the market can be also an efficient means to coordinate the overall research system (and not only the small-scale project funding markets). In wider social terms, this reflects the assumption that becoming a leading research system will also trigger down to reach other social goals (Amable, Barré and Boyer 1997). A key requirement is however that research performers enjoy of sufficient autonomy to orient themselves to research services demand and not to pursue other goals, like education or regional policy goals. Strong institutional autonomy of performers and the social acceptance that research quality (as measured by proposal evaluation and performance) has to be the main goal of laboratories are thus prerequisites of this model.

Under these conditions, one would expect that cumulative advantages lead to the concentration of research capacities in a limited number of players (with some segmentation by submarkets) and thus to a strongly stratified system; however, a parallel requirement would be the size of the system being sufficiently large to avoid building an oligopolistic system which would reduce competition and, especially, diversity, an outcome which as been demonstrated in the very small-scale Estonian system (Masso and Ukainski 2008). Unsurprisingly, the largest integrated research system in the world, the American one, is the best case of this model.

4.2 The mixed model

While no country relies today exclusively on core funding, in most Western European countries this channel represents the main share of funding, however supplemented through a substantial volume of project funding (between 1/3 and ¼ of the total amount).

This model can be analysed in terms of complementarities between the two channels: core funding to universities and PROs allows for a broad repartition of research funding (with different levels of selectivity depending on the allocation mechanism), while project funding allows to reward selectively the best research groups (for example through research council’s grants) or to promote the development of specific research areas through thematic programs. This can fit a more equalitarian logic where it is assumed that research capacity should be spread throughout the higher education system, also because of its benefits for education and for regional development.

However, to have this model function reasonably and be perceived as equitable, differences in reputation and quality between individual universities should be small enough to have core and project funding work as complementary instruments (and not just core funding sponsoring lower level research laboratories). A further issue concerns coordination at the system level, since this model lacks the strong concentration forces of the project-funding based model and thus might lead to fragmentation and duplications (because also of overlapping and non-coordinated strategies of higher education institutions and funding agencies). The introduction of specific instruments to promote networking and coordination – like networks and centres of excellence and cooperation schemes – is a widespread recipe to solve this problem.

There are some reasons to argue that this model can function well especially in rather small-scale and financially well-endowed systems: small-scale systems can be more homogenous concerning the quality of their HEI, while a rather high level of resources means that there are resources also to promote research in less-reputed institutions without damaging the overall scientific performance of the country; moreover, coordination through networking works best in sufficiently small-scale environments. This model is thus typical of some middle-size highly developed European countries, like Netherlands, Norway, Finland and Switzerland. Interestingly, all of them possess binary higher education systems, thus effectively shielding the core of research universities from large number of students and separating academic from practice-oriented higher education (Kyvik 2004).

Countries where the higher education system is larger, either because of size and of its structure, might have more difficulties to cope with a larger number of players to coordinate, respectively with large quality differences between higher education institutions (especially for unitary system with many young institutions created to cope with increasing numbers of students). An option to address this situation is to strongly stratify the higher education system through selective core funding; in the UK the RAE effectively selected a top-group of 10-20 universities where research capacity is concentrated, shielding it from new universities and old polytechnics. A different choice would be to focus higher education institutions on education and to establish large vertically integrated research performers.

4.3 The vertically integrated model and its evolution

This model adopts a single large-purpose research organization as the main coordinating device of the funding system. Of course, the system can comprise also other research organisation (especially mission-oriented like in the French case), as well some research activities in universities, but it is clear that in terms of volume, reputation and policy the national organisation is the main actor in the research system.

This model characterised most Central and Eastern European countries under the communist regime and, to some extent, also France until the ’70, with the dominance of the CNRS (as well as of some other large-
mission oriented PRO's). It was thus typical of centralised systems with strong state planning. However, countries like Spain (CSIC), Italy (CNR) and, to a lesser extent Germany (MPG) adopted a similar approach. In general terms, this model can be seen as a way of avoiding some of the problems of the university-based model in systems where the average quality of university research was rather low and too diverse from institution to institution.

In its pure form, this model has ceased to exist in developed countries after the breakdown of the communist regimes and with the fundamental changes in the organisation of public research in France (Mustar and Larédo 2002; Theves et al. 2007). The only surviving case is probably the Polish system, where the State directly centralised the allocation of funding to individual laboratories and university departments in the research and higher education ministry (Lepori et al. 2008). However, the model shows a relevant evolution in number of countries, where the national large-purpose research organisation is still a major actor in the public research system and a recipient of core funding, alongside higher education institutions. Different evolutionary variants emerged including the specific setting of CNRS with its joint laboratories in universities (Theves et al. 2007) and pushing large PROs to diversify their funding base and to compete for competitive funding, like in the case of the Spanish CSIC (Sanz-Menendez and Cruz-Castro 2003). It seems largely open to which extent these hybrid forms are stable or will progressively evolve towards one of the former model, with a clear separation between funding agency function and performers organisation function.

5 Conclusions and perspectives

The concepts and ideas developed in this paper do not aim replacing the approaches reviewed in the introduction, which have proven to be extremely valuable for understanding different aspects of public research funding systems and are able to nurture a rich tradition of studies. In this context, the specific contribution of this paper can be identified at three levels, namely concerning the overall framework of analysis of funding systems, concerning the classification of funding instruments and arrangements and, finally, on how to characterize and compare national funding systems.

Firstly, my contribution has been to introduce concepts and categories to examine funding systems in terms of the (collective) interaction between funding agencies and performers and how it is framed by a specific institutional context (largely constructed and maintained by the actors themselves), thus bridging studies focused on the funding side with those centred on performers strategies. This addresses a well-known limitation of principal-agent approaches - which focus on actors’ choices and largely consider institutional frameworks as exogenous and limited to formal arrangements – and reintroduces socially shared values and norms as a key factor in shaping the relationships between funding agencies and performers (a well-known theme in science studies). Moreover, this approach allows better considering multiactor interactions – both involving performers and funding agencies – and their impact on allocation of funding. This is particularly relevant in today’s highly differentiated and multilevel systems, where there is not anymore a dominant funding agency for each main funding task and agencies jurisdictions tend to superpose (for example between European and national agencies).

Further, this approach drives to go beyond the traditional focus on national funding systems. Namely, the relevant systems borders are not any more defined exogenously based on legal or geographical distinctions, but should be derived empirically from the observation of the stable and relevant patterns of interaction between actors (as well as of shared norms and values). Of course, in the aggregate of all domains and funding flows the national level is still the most relevant, but this might change when looking to specific domains of science. Thus, in some areas and for some performers it could well be that the strongest interactions are between performers and European funding agencies, while in others regional spaces are the most relevant; this would drive to define accordingly the relevant delimitation.

Secondly, in terms of classification of funding instruments, this approach addresses some limitations of taxonomies based on the characteristics of funding instruments and agencies alone, like the widespread distinction between institutional and project funding, for example providing a rationale for considering network instruments as a specific coordination mode. The argument here is that the most relevant properties of funding arrangements for the development of science, like the extent of delegation, the level of competition, the ability to let innovation develop are features of the interaction between funders and performers and thus cannot be correctly analysed by looking to the funding instruments and agencies alone. A further reason of interest is that one could take stock of studies in institutional economics and socio-economics introducing evaluation criteria for institutional arrangements – including efficiency, enforceability, equity and ability to produce public goods (see Hollingsworth 2002) – to evaluate the functionality of funding systems and their compatibility with their wider institutional context.

Finally, for the comparative analysis of national funding systems, I suggest that focusing on coordination modes and institutional complementarities could be a promising avenue to systematically compare different national systems and possibly bring this field beyond the opposition between assuming convergence towards a unique model and emphasizing the national institutional and historical specificities. Of course,
what has been presented in the last part of the paper should be considered as an exploratory attempt in this direction. A sounder empirical validation would certainly require the identification of parameters and descriptors allowing to characterize funding arrangements and to compare systematically systems, for example using clustering techniques (see Amable, Barré and Boyer 1997 for the case of Social Systems of Innovation and Production).

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