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Understanding & Assessing the Impact & Outcomes of the ERC Funding Schemes

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Public Sciences and Change: Science Dynamics Revisited

Introduction

Science is a dynamic system and it has always changed in response to imperatives generated by its interactions with other domains of social production. During the last three or so decades public science systems[1] in different national and international contexts have been experiencing an unprecedented rate of change that affects their different aspects. These include the organisations of science, both universities and research institutes, the relationships between the organisations of science, the state and industry, knowledge communities and their structures and modes of operation, and the nature, essence and conditions of access to knowledge. Furthermore, there has been a proliferation of mechanisms, policies and policy instruments aiming to increase the control of human societies and the state over science. In this context, scientific knowledge, scientific communities and scientific organisations have been cast as the engines of industrial competitiveness and economic progress. Specific types of knowledge are being harnessed and their producers, knowledge communities and research organisations, subjected to a number of policy pressures for change predicated on achieving a desired outcome.

These processes create powerful imperatives for increasing the understanding of the workings and dynamics of science. But, as I argue in this paper, while valuable bodies of research and literature are building up the accounts usually cover discrete areas of science and/or are overwhelmingly empirical. Being so, current accounts of science and change do not generally afford analysis, understanding and/or analytical comparison between different social environments. This paper aims to make the initial steps towards bridging this gap. The focus here is not on what has changed but rather on the possible ways to conceptualise and study the dynamics of science.

It is suggested that a framework allowing useful analytical comparison of the dynamics of the sciences is one viewing science as a matrix relationship between research fields and research spaces whereby the research organisations are the nexus

linking these. Moreover, viewing science as a matrix relationship between research fields and research spaces is useful in dealing with five problems of the study of science dynamics. These are identified as the fragmentation of studies of science change; acute issues of attribution of change processes; developing frameworks for analytical comparison; explanation and charting change trajectories; and understanding the links between policy generated pressures for change and the transformations affecting research organisations, knowledge communities and ultimately bodies of knowledge.

Science: accelerated change

Over the last several decades we have witnessed a range of accelerated changes in public science(s). There is evidence that these transformations have most obviously affected the social organisation of science both as organisations and knowledge communities, and the form and nature of the interactions between science and other domains of social production like the state, industry and commerce. It is probably safe to assume that the transformations affecting the social organisation of science will eventually although not immediately begin to change the nature and essence of the knowledge being produced although the evidence on that is still not decisive. At the same time the complex and multi-faceted relationships between exogenous pressures for change; the organisations of science and the knowledge that is produced and legitimised are far from well understood.

In terms of the organisations of science *universities* are considerably better studied than the research institutes. A number of debates relating to the changes affecting the universities have developed covering its governance; proclaiming the rise of the 'entrepreneurial' university and rejoicing in or bemoaning its effects and consequences (Clark 1998 and 2001; Etzkowitz 1994, 1998 and 2002; Jakob et al., 2002; Marginson and Considine 2000; Yokoyama 2006; Nedeva and Boden 2006); and the 'third mission' of the universities and its transforming potential (Floud 2003; Molas-Gallart et al. 2002; Jones 2002; Thorn and Soo 2006; Martin and Etzkowitz 2000; Nedeva 2007).

Contributions to the debate on the changing governance of the universities range from fairly trivial politically motivated accounts of management techniques

[1] For the purposes of this paper science is defined as public according to the conditions of access to the

(Shattock 2003) to innovative interpretations and analysis of academic leadership (Fuller 2007). Fuller, for instance, conceptualises the latest changes facing the university or "…the university's current predicament" (Fuller 2007: 50) drawing on parallels with the state and the church. In this context Academic Ceasarism refers to "…both the promise and the peril of universities' acquiring leaders who so strongly identify with their institution that they may feel they must protect its identity even from its own academic constituency" (Fuller 2007: 50).

Another important line of discussion concerning the change of the university proclaims the rise of the 'entrepreneurial' university. Although the quality of their empirical base is seen to vary considerably (Deem 2001) all authors argue that the universities are undergoing a profound process of transformation along the lines of commercial relevance of their research and teaching.

Barton Clark, for instance, links the rise of the 'entrepreneurial' university with the fact that universities, particularly the ones dependent on public funding, are unable to respond effectively to the pressures and expectations placed upon them. Thus, universities are beginning to reconsider their functions and missions, and to undergo organisational and structural change so that these are better able to meet the growing (state) expectations for commercial relevance of their activities (Clark 1998). Henry Etzkowitz claims that the universities are undergoing a 'second revolution' (Etzkowitz 1998) while Merle Jacob et. al. (2003) and Kazuki Yokoyama (2006) trace the 'entrepreneurial' university through a range of structural and organisational transformations in terms of governance, funding and management. Simon Marginson and Mark Considine also argue that a new institutional type of university is emerging. This is distinguished by the way its purpose is defined, by the advent of its corporate character, by the emergence of new and shadow governance and management structures and the development of 'pseudo-markets' (Marginson and Considine 2000).

Directly associated with the studies of the 'entrepreneurial' university are the discussions and interpretations of the 'third mission' of the universities or the 'third' stream of activities. In this context the changes affecting universities are discussed as part of the more general recasting of the universities as agents of the 'knowledge society' (Nedeva 2007; Martin and Etzkowitz 2000). Correspondingly, the third

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knowledge it produces rather than depending on the sources of its financing.

mission has been broadly defined as the imperative for the universities to contribute to wealth creation, regional and national competitiveness, quality of life or generally to support and provide service to non-academic environments (Floud 2003; Molas-Gallart et al. 2002; Jones 2002; Thorn and Soo 2006). More importantly, most attempts to define the third mission of the universities are functional and try to outline it as a set of activities. This in turn blurs the transforming effects that the third mission has on the universities and focuses the debates issues around its novelty and/or normative implications (Martin and Etzkowitz 2000). Other, more analytical, accounts redefine the third mission of the universities "…as the institutional imperative of the university to engage in a variety of exchanges with non-academic domains thus establishing different kinds of relationships with societal and economic/industrial agents" (Nedeva 2007: 94). The notion of the third mission of the university as relational unmasks the fact that it is not about the universities absorbing new functions and activities but creates imperatives for the organisations to re-consider the way in which their existing activities (e.g. teaching and research) are being carried out. Hence, by actively adopting the third mission the universities are embarking on a journey of accelerated organisational change.

The interest in the workings of the *research institutes* is less intense than this in the universities. Accounts of change or even analytical interest in the research institutes usually originate either within environments where these organisations have a research function similar to those of the universities (like France, Germany and partially Spain where understanding research is carried out at research institutes) or dramatic transformations have taken place.

Pierre Joly and Vincent Mangematin, for example, have analysed one of the large research organisations in France, INRA, and the dynamics of its relationships with industry. The authors have explicated some of the effects that the relationships of a research organisation (laboratory) have on its research choices and mode of legitimisation (Joly and Mangematin 1996). Luis Sanz-Menendez and Laura Cruz-Castro have provided a detailed account of the reactions of public research organisations in Spain to the reduction of direct public financing (Sanz-Menendez and Cruz-Castro 2003). Philip Mirowski and Rob Van Horn, direct their attention to the contract research organisations (CROs) and their role in the process of commercialisation of research. Studying a number of CROs in the biopharmaceutical

sector the authors "…confront the wider implications of the modern regime of commercialized science…" (Mirowski and Van Horn 2005).

Boden at al. also provide a detailed empirical account of the privatisation of the Government Research Establishments (GRE) in the United Kingdom (Boden at al. 2004). The authors also argue that the privatisation of the GRE, although executed with wilful determination by the Tory government, resulted from the strong ideological beliefs of a group of ministers rather than perceived social necessity (Boden at al. 2006). This coupled with a high level of complexity means that both the spill over effects of the reform and the future of the 'privatised' GRE were unpredictable, are still unclear, and some of these are very likely undesirable.

During the last three four decades the *relationship between the state (government) and science* has also changed quite dramatically. One aspect of the these changing relationship involves the transformation of the 'funding regime' of public science along the lines of increased accountability, selectivity and competition for resources (Shore and Wright 2000; Nedeva and Boden, 2006). This, in turn, is associated with the development and implementation of different national and transnational systems of control (Whitley and Glaser 2007; Bence and Oppenheim 2004; Henkel 1998; and Cooper and Otley 1998). Essential and inevitable elements to transforming the relationship between the state and the publicly funded science are the research intermediaries, and their changing functions and structural positions in this context has been discussed by Barend van der Meulen (2003), Dietmar Braun (1993), Chris Caswill (2004) and Nedeva and Boden (2006).

Steering public science towards a closer and more direct relationship with users, and more specifically industry and commerce is part of the general overhaul of the relationship between the state and science. This, however, has affected some changes in the customary relationship between science, industry and commerce. In the literature different aspects of this change are discussed including the increase in number and strength of links/interactions between universities and industry; the increase in number of spin out/spin off companies; the boundary conditions (policies, incentives) for this process of intensifying interaction to continue etc. Formidable numbers of publications have emerged on each of these general themes/issues.[2] It

[2] Here it might be worth noting that whole journals in STS have come to be dominated by such and similar issues and that a very basic Google search yielded a list of almost half a million publications on academy industry links and spin off companies.

would be fair to say, however, that most of these report empirical results (measurement), discuss even more refined methodologies and techniques to measure academy-industry links but rarely question their rationale and/or possible consequences. More often than not research in this area falls into the trap of policy research, namely providing justification and advocacy rather than critical discussions of policy steered processes.

To summarise, a process of accelerated change is clearly affecting different aspects of science. These transformations have attracted considerable research interest and research in the area is generally robust where registering change is concerned. However, there are at least five distinct problems associated with the current study of science and change.

Firstly, even a fairly broad-brush look at the literature on science and change illustrates that research and analysis are fragmented and confined within particular aspects of science rather than grounded in conceptual frameworks accounting for the linkages between these. So, for example, the changes affecting the universities are very often discussed without consideration for other research organisations, or their relationships with a multiplicity of funders and other organisations.

Second, this in turn precipitates problems with attribution – change can be registered and argued as the difference between the state of affairs at two different points in time but not *attributed* to particular pressures or drivers. It is not surprising therefore that where attribution of change is concerned researchers often resort to the help of general categories such as 'neo-liberalism.'

Thirdly, accounts of change processes in science are usually fairly localised. In other words transformations have been studied in particular cultural and social environments and conclusions regarding the nature, scale and implications of change are valid only within strictly defined boundaries, both conceptual and geographical. There are very limited, if any, opportunities for analytical comparison and even more importantly there are no conceptual conditions for comparative frameworks to emerge. Often in the more recent accounts, claims regarding change processes are either exaggerated (e.g. claiming the transformation of 'the university' when meaning a particular group of universities in a particular locale) or end up with tick-box descriptions of localised findings.

Fourth, since conceptual frameworks allowing researchers to deal with attribution and comparison are still lacking, existing accounts of change are generally

founded upon fairly sophisticated ways to measure it. Whilst part of the accounts go some way towards explaining particular transformations these generally cannot predict change trajectories or draw any conclusions about the possible effects of change. In other words, in the absence of a coherent conceptual framework for studying science and change the problem is "…that discussing the future leans toward "social science fiction" embellished by melodrama of either very favourable or very catastrophic projections. In fact, much of the future – as with the past and present – is banal" (Thelin 2003: 54).

And last but not least, there is no sufficient understanding as to how societal and political pressures for change affect the organisation of science and the nature of knowledge. With very few exceptions, concepts currently dominating the science studies and science policy areas focus exclusively on the relationships between actors (national innovation systems); the relationships between science, the state and industry (the Triple Helix) or argue dramatic discontinuous change while not going into its detailed workings (Mode 1-Mode 2 concepts).

Towards a conceptual framework

Looking at the established and rather rapidly developing bodies of literature on different aspects of science change not only evidences the processes of accelerated change but also brings to the fore five distinct problems. First, accounts of the transformations affecting contemporary science are fragmented in that these usually refer to one of its aspects and generally ignore the links between these as well as lack outlets to policy more generally. Second, the study of change in science faces acute problems of attribution whereby whilst change processes can be measured no conclusions regarding their producing mechanisms and their broader effects can be reliably reached. Third, there are no frameworks allowing analytical comparison of change processes. Fourth, contemporary studies of change are becoming more sophisticated in developing measurement techniques but have problems with explanation and mapping change trajectories. Fifth, and more fundamentally, the ways in which policy generated pressures for change affect, or not as the case might be, the organisations of science and scientific knowledge are still not well understood.

In this part of the paper a conceptualisation of science as a matrix relationship between research spaces and research fields is proposed. Such a concept of science, I believe, is helpful conceptually and methodologically in if not immediately re-solving

the problems with the study of change discussed above, then at least preparing the foundations for this to occur.

This conceptualisation builds upon the belief that understanding the dynamics of science is to a large degree conditional on understanding science itself. Understanding science in turn by necessity incorporates the dominant notions about science, the organisation and organisations of science, the interdependencies between the cognitive and social organisation of science and the socio-political environment of science and its governance.

The framework proposed here is a conceptualisation of science in terms of a matrix relationship between research spaces and research fields. It builds on previous work, most notably by Richard Whitley (2000), Rikard Stankiewicz (2002) and Andrea Bonaccorsi (2008). Some assumptions of new-structuralism also underpin this conceptualisation (Wellman and Berkowitz 1988).

Utilising a notion of science as the matrix relationship between research fields and spaces is analytically useful for understanding its dynamics, particularly in the context of policy-initiated change. Such conceptualisation emphasises the complex relationships between the different aspects of science and can provide a platform for overcoming at least some of the conceptual and methodological issues associated with the study of science dynamics discussed in this paper.

Research fields

Richard Whitley has defined research fields as "…reputational units of research work organisation which reward innovative contributions to collective intellectual goals; control material rewards through public reputations; combine collegiality with competition; and direct research to achieving intellectual influence" (Whitley 2000: 34). Immediately following from that, 'research fields' can be seen as empirically outlined by three inter-linked elements, namely converging *knowledge communities*, consistent *bodies of knowledge* and *research organisations*.

Knowledge communities are groups of researchers (academics) who share similar or commensurate epistemic assumptions, methodologies and have developed consistent systems of reputational control. Members of specific knowledge communities, by the virtue of sharing fundamental assumptions, methodologies and techniques and rules and scripts, are involved in intensive interactions founded upon the exchange of information (Crane 1972), knowledge flows (Knorr-Cetina 1999) and

reputational hierarchies. Hence, knowledge communities can be empirically accessed as relatively persistent social networks.

Being social and cognitive networks, knowledge networks emerge and organise around convergent bodies of knowledge[3] and cut across organisational and national boundaries. Knowledge networks persist through developing a range of 'crystallising agents' (Luukkonen and Nedeva, forthcoming) which apart from bodies of knowledge include journals, conferences, research equipment and facilities and principles of research training. Through sets of complex interactions these communities produce and reproduce cognitive understandings and provide the standards for problem selection as well as those for the legitimation of new knowledge. Participants in knowledge communities are also part of research organisations and depend upon them for funding and other resources, and to facilitate their research work.

Customarily, research organisations, both universities and research institutes, are presented as knowledge producers. One implication of the conceptualisation of knowledge as a matrix relationship between research fields and research spaces, however, is that a clear distinction between 'the units of resource' and the 'units of production' in science emerges. In other words, organisations are the legal unit of resource in science and as such fulfil a number of important functions. To mention but two of these functions, research organisations enable their staff to be effective knowledge producers and participants in knowledge communities, and universities are the custodians of the 'knowledge commons'.

Such a conceptualisation of the notion of 'research fields' has clear implications not only for the study of science dynamics but also for the investigation of different institutional mechanisms in science, most notably individual careers, career paths, career structures, mobility and institutionalisation processes and practices.

Research space

The research space is defined by the 'essential' relationships of the research organisations and by layered notions of the utility of knowledge. The emphasis is on

[3] A way to think of these bodies of knowledge is to see them as 'knowledge pools' combining both understanding and transforming type knowledge. These knowledge pools can be disciplinary or

the relationships and the exchange(s) in which the organisational actors are involved rather than on the attributes of the organisations. In other words, in difference to the concept of National Innovation/Research Systems, for example organisational attributes are conceived as secondary to the type of exchange that legitimately could occur in the context of the relationships.

The 'essential' relationships of research organisations are outlined by the essential exchanges in which these engage. At the most general level this is the exchange of resources for knowledge. In terms of resources the organisations of science engage predominantly (although not exclusively) in exchanges involving money[4]. Where knowledge is concerned the exchange can involve knowledge embodied in science artefacts (academic papers, books, research reports, data sets, equipment and facilities, techniques, new molecules etc.) and/or knowledge embodied in people (competencies). Although the organisational actors are likely to vary between different research spaces these would broadly be state/government organisations, industrial and commerce organisations and possibly (but not necessarily) charity organisations. While research intermediaries are part of the research space they do not define it.

Irrespective of the kind of organisations involved in exchange with the research organisations this can vary from money for knowledge (without strings attached) to money for knowledge the parameters of which have been directly or indirectly specified. Existing 'notions of utility' of knowledge frame the concrete form the exchange takes as well as its legitimacy.

How these notions of utility form (are negotiated) is an important issue but cannot be a part of this paper. It is important to note, however, that the different organisational actors in the research space enter the relationships with their own notions of utility. The exchanges (and respectively the relationships) in which the organisations of science engage change following change in the notions of utility of the power side of the relationship. Historically the notions of utility of science have

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thematic and form around shared epistemic assumptions, methodologies, perspectives, data sets and other types of infrastructure etc.

[4] To an extent this is a necessary simplification as the relationships by their very nature and necessity involve more than one kind of exchange. However, the exchange of money for knowledge is the essential one since money is the one resource that research organisations cannot forego and which can be controlled by other actors. In other words, in terms of the relationships of the research organisations money is the most obvious source of power and influence.

included 'science as a curiosity,'[5] 'science as a reputational artefact,'[6] 'science as a common good' and 'science as an economic good.' These are not mutually exclusive and can actually co-exist.

So for example, notions of utility seeing science as a common good are likely to precipitate a relationship based on the exchange of money for knowledge whereby there are no clearly articulated requirements (expectations) towards the nature of the knowledge, its domain or its relevance for resolving pressing problems of society and the economy. Thus, the conditions of use of the knowledge produced are fairly loosely defined as well but there is an expectation that it will contribute to the 'knowledge commons'. Such relationships are likely to be mediated (if at all) by research intermediaries that are either buffers (like the University Grants Committee was in the UK, for example) or have the characteristics of a 'republic of science' (as the Research Councils and other similar organisations used to be). It is worth emphasising that if this type of notion of utility shapes a relationship it will share the characteristics mentioned above irrespective of whether this involves state/government organisations or industrial organisations.

Conversely, the notion of science as an economic good is associated with expectations for immediate usefulness of all scientific knowledge. In this context the relationship that is formed is one where the exchange is money for knowledge that meets specific predefined criteria. Such relationships are predicated on funding regimes dominated by competition and selectivity. Science in turn is expected to be able to account for the resources invested in it by producing knowledge that clearly contributes to wealth production and quality of life. The exchange is monitored and controlled whereby dedicated tools and mechanisms for that emerge/are set up (the Research Assessment Exercise in the UK, for example).

An important point here is that tensions in the relationships emerge only when the notions of utility of the organisational actors are different and incompatible. In such cases the exchange is normally shaped to reflect the notion of utility of the more powerful actor. This in turn can lead to one of three possible courses of actions by the

[5] During its early years part of science was supported by wealthy patrons not only because of the curiosities that it produced but also for more mystical purposes. Some temples in ancient Greece, for example, used steam engine technology to impress the non-initiated.

[6] Relationships of patronage between medieval states and science are framed by this notion of utility. Example is provided by the early Italian academies.

less powerful actor in the relationship: i) game playing; ii) organisational change and eventually realigning of notions of utility; and iii) break down of the relationship.

This point can be illustrated by a situation where, for example, the notion of utility of the government organisations is that scientific knowledge ought to be universally, immediately and economically useful and that of the universities is that all knowledge is ultimately useful. If that were the case the relationship will be structured to reflect the notion of utility of government. In such a relationship access to resources is likely to be subject to intense competition and/or selectivity. This in turn implies that criteria for selection are developed as part of a more general process of increased monitoring, evaluation and control. These criteria apart from containing a steer as to the type of knowledge that is 'useful' are a combination of ones relating to the quality of research and knowledge and ones associated with the use of knowledge. This is evidenced in the UK by including potential users in most, if not all, funding decisions (including funding from the Research Councils).

The universities' notion of utility, on the other hand, is that all knowledge is ultimately useful which goes with related notions of free enquiry and institutional autonomy. It also engenders an exchange whereby the knowledge produced by the universities while exchanged, is gifted rather than bought and where their duty is to be the custodians of the knowledge commons. One possible course of action here is for the university to try to defend its notions of utility (and all it engenders) by game playing. Examples of such game playing is the changing format of writing proposals whereby statements regarding the usefulness of the research are strongly exaggerated. Another example is provided by the RAE in the UK where game playing begins with the universities competing to place their academics (or academics sympathetic to particular research orientations) on the panels. Universities also embarked on rounds of mock assessment exercises and evaluations, with academics deliberately subjected to pressure to publish in particular journals seen as highly ranking by the RAE etc.

Another possibility in the context of a relationship where notions of utility are incompatible is that the weaker side embarks on a wide range of organisational change eventually resulting in re-alignment of the notions. As discussed in another part of this paper, one example is that the universities have been transforming their organisational missions and generally transforming their organisational structures.

And a third possibility is that the relationship breaks down. For example this would be possible if the universities (or at least some of them) either accumulate

sufficient independent wealth so that the exchange becomes non-essential or, more realistically a new relationship founded on compatible notions of utility is established.

It is also worth noting that the pressure for change in the context of the proposed framework is not a result of a particular relationship but an aggregate of all the relationships of the research organisation.

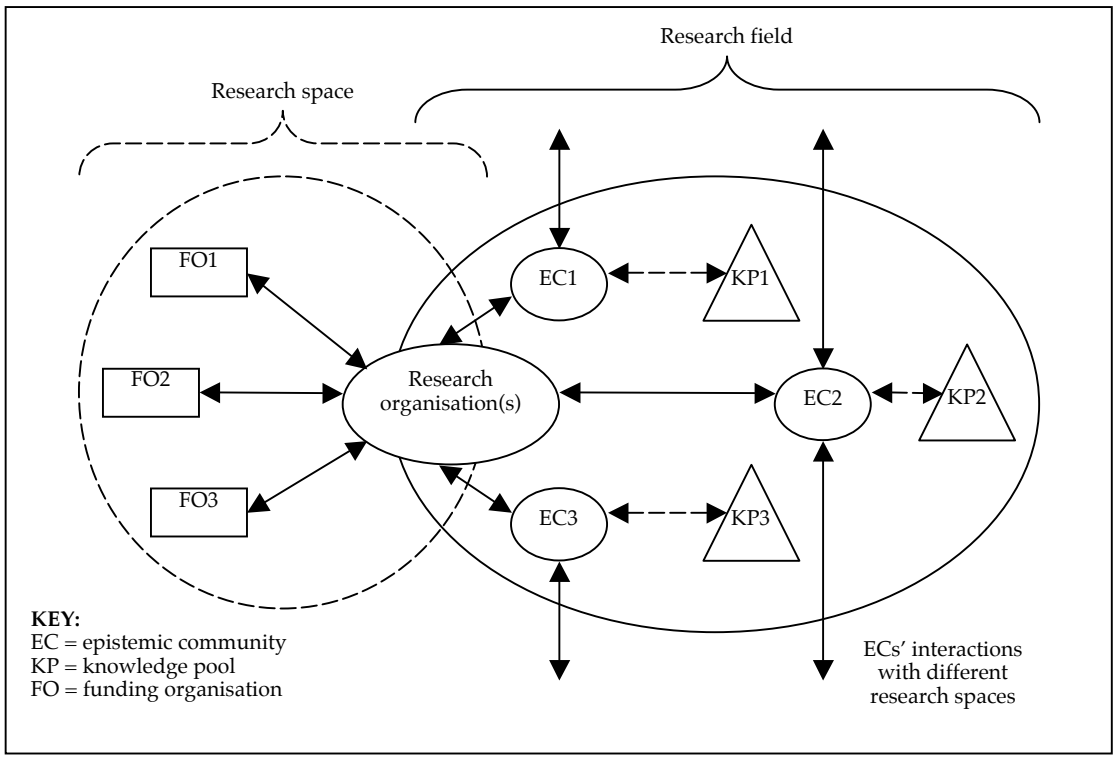
Science as a matrix relationship between research fields and research spaces

A possible conceptual framework for studying public science and change is one where science is conceptualised in terms of a matrix relationship between research fields and research spaces, as outlined above. In this context, the research fields are empirical entities encompassing knowledge communities, bodies of knowledge and research organisations, whereby the research space is defined by the essential relationships of the research organisations and by notions of utility of knowledge. In this sense, organisational attributes are seen as secondary to the legitimate types of exchange in which organisations populating the research space are involved. It is also important to emphasise that the research space comprises a number of diverse organisational actors and its core characteristics are shaped by the interactions between the organisational actors rather than the specific attributes of these organisations. Figure 1 provides a graphical expression of this concept.

One of the most obvious implications of viewing the dynamics of science as a matrix relationship between research fields and research spaces is that the research organisations are the nexus connecting these. Being so, research organisations are the intermediary between non-research domains, the epistemic community and the bodies of knowledge around which that community is organised. In other words, the research organisations are the prism through which pressures for change and tensions in the relationships generally are translated.

It is also worth noting that the members of the knowledge communities participate in and interact with a number of different research spaces. Thus, the scripts, reward and control systems of the epistemic communities and the research organisations that provide the resource base to its members can, at least in theory, be different. A number of tensions can arise if this is the case and can affect not only the ability of researchers to be effective (prominent) members of communities but also the very aptitude of the community to produce knowledge.

Figure 1: Matrix relationship between research fields and research spaces



Another major tension in the context of this framework is the one arising in the context of the discrepancy between differentiated research fields and usually undifferentiated research spaces.

Apart from aiding the empirical study of the dynamics of science this kind of reasoning can enable the re-framing of policy rationales. An example here is afforded by the policy attention that 'integration' has been getting in the context of the European Union's drive for achieving the European Research Area (ERA). The policy rationale here is normally provided by the so-called 'gap' argument, according to which Europe is falling behind the United States in terms of science and (particularly) its application. This failing is attributed to the perceived national fragmentation of research in Europe and therefore the worked out solution is to create instruments and platforms aiming to integrate the science systems.

Looking at Figure 1, however, it is apparent that i) knowledge communities are always 'integrated'; and ii) that their performance overall as well as the performance of individual participants is conditional upon the extent to which the research organisations provide an adequate base. In other words, the issue can be

framed as one about building up organisations rather than encouraging further networking.

Instead of conclusion

In this paper I argued that an accelerated process of change affecting different aspects of public science is taking (has taken) place. Whilst this creates powerful imperatives for more profound and refined understanding of the dynamics of science, existing conceptualisations are fragmented, have problem with attribution, do not allow comparisons of change processes across varied environments, cannot explain or map change trajectories and fail to provide a theoretical framework for studying the effects of policy generated pressures for change on research organisations, knowledge communities and bodies of scientific knowledge. I also proposed an outline of a conceptual framework that builds upon existing conceptualisations and also uses some of the assumptions of the new structuralism.

Instead of a conclusion it is probably worth asking the question as to whether, and to what extent, the proposed framework goes some way towards helping us to deal with the issues related to the study of change outlined above. Thus the proposed framework provides a basis for overcoming the fragmentation of empirical accounts and conceptualisations of change by emphasising the importance of the relationships forming between the different aspects of the research fields and the research space, on the one hand, and the organisations populating the research space on the other.

The proposed framework also helps overcome the problem of attribution by reversing the primary focus of analysis. Using this framework the analysis does not start from measuring change (as difference, for instance) then attempting to attribute it. On the contrary the analysis starts from mapping research spaces and identifying tensions and pressures for change building within these and than tracing the ways in which they have affected, or may affect, different aspects of public science.

Most comparative frameworks use attributes of social entities as their foundation. Conceptualising science as a matrix relationship between research fields and research spaces, and emphasising the relationships that frame them suggests that an alternative way might be to use the concept of structural equivalence. Moreover the proposed framework goes some way towards facilitating analytical comparison between change processes grounded in different environments (research spaces). Shifting the analysis from organisational attributes to relationships, exchange and

notions of utility allows one to place registered difference in the context of local rationality.

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