A Network Approach to Studying Research Programmes: Mobilizing and Coordinating Public Responses to HIV/AIDS

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ABSTRACT *Based on the analysis of the Medical and Public Health Research programme (Commission of the European Communities), the paper shows how new scientific communities are created in response to the HIV/AIDS problem. We analyze how actors are mobilized (three mobilization modes: public impetus, scientists' initiative, scientists' initiative with public networking) and how their work is coordinated. We defend the hypothesis that these new scientific communities are flexible cooperation networks. In the case of AIDS research, there are only a limited number of network types (the data collection structure, the forum, the thematic partition with harmonization of research practices, the starred around a central facility). The coordination of these scientific cooperative networks passes through fixed and circulating intermediaries. The management of these intermediaries is a major activity for involved actors. Thus, our aim is not to study the wider social context, but to analyze networking in response to policy initiatives.*

Introduction

When a new problem appears in society, public authorities occasionally have to develop and implement specific intervention programmes. A crucial step is to mobilize the interest of various allies and coordinate some of their activities. We have investigated how scientific actors are mobilized, and how their responses to the AIDS problem are coordinated. Our investigation centres on the CEC's Medical and Public Health Research (MHR) programme. Using this example, we describe the successive phases in mobilizing scientific actors and constructing specific intervention systems. We demonstrate the role of public authorities in building flexible cooperation networks, which are an adaptable and rapid way to mobilize and coordinate to meet new challenges. We also underline the importance of intermediaries in coordinating scientific work.

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Mobilizing Researchers and Public Authorities

Our first investigations involved the reciprocal mobilization of both scientists and public authorities. The interest of both types of actors in the problem must be solicited and they must become enrolled.

It is a myth that researchers live in an ivory tower in a scientific community governed solely by ethical codes and coordinated by communication systems (publications) and signs of recognition.[1] They are mobilized by causes other than scientific method and the 'ethos of science'. Scientific research is permeated with and sustained by relations and activities that reach beyond the laboratory and specialized community. The wider context of scientific activities[2] is demonstrated in several different ways: scientists write letters, send drafts of articles and submit research proposals. They make phone calls throughout the world and travel to meetings with industry, or they belong to scientific councils that manage public research interventions. After these meetings and trips, they modify their proposals and redraft their articles. Rewriting often forces them to substantially revise parts of their research. Research is thus structured by its implications beyond the laboratory and outside its specific field. Thus, enquiries are continued or abandoned according to industry's response. Negotiations to procure funding, data or equipment, or to place staff have immediate repercussions on the content of research. Furthermore, researchers are regularly caught up in scientific controversies (among themselves or in public) in which scientific and technological choices are articulated in the interests of specific social groups.[3] Scientific and technical content is thus negotiated; it is not determined solely by membership in a given speciality, but is the result of interaction with other social actors. Scientists are thus integrated into networks of people and reasoning that do not reflect the broad categories of science or field of research.[4] With the sociology of translation, Callon[5] demonstrated how the various actors mutually defined one another by elaborating problematizations (i.e. articulations between human or non-human entities), by building means to solicit interest, and enrolling allies. Knowledge thus becomes a resource used by scientists in the pursuit of their interests. It becomes a social and cultural resource drawn from their work, enabling them to displace their allies and create new social conditions.

A research proposal that receives state funding can therefore be seen as a chain of translations of problems that begins by defining a need or goal (in medical, social, political or economic terms), then proceeds to a choice of methods, materials and research processes. Throughout this series of choices, funding agencies and scientists negotiate the problem's definition and how it can be translated in a research programme. The researcher's contextual implication corresponds to the choice of content, whereas public authorities' mobilization of researchers corresponds to a redefinition of the goals and policies. This analysis enables us to understand the factors underlying relations between the scientific community and the world of public authorities.

Let us now examine how, as a general rule, these multiple local interactions and micro-events shape and regulate scientific research and policy. To do this, we have referred to the 'credibility cycle notion' suggested by Latour[6] and later developed by Rip.[7] This notion underlines efforts by researchers to mobilize various resources. On one hand, it shows how one type of resource is transformed into another (scientific articles into funding, funding into equipment and staff, all part of a process of productive research that in turn leads to new articles), and on the other, that these transformations are determined by recognition of findings. Scientists must fight to have their results recognized (which Rip calls the 'struggle for facticity').

The credibility cycle notion encourages anyone observing researchers at work to

leave the laboratory and analyze the flow and transformation of resources. The observer then discovers other fora where scientific work is organized and regulated, in particular research councils. At this level, researchers are constrained by institutions which also provide the same researchers with legitimacy. At the same time, scientific production transforms science's organization and social context. Local production of knowledge leads to changes in the delocalized socio-scientific realm. To identify the mechanisms at play, Rip adapted the credibility cycle notion and applied it to research councils. He justified this shift by the fact that these councils, just like researchers and laboratories, must earn their budget by proving to their governments and the public that their money goes to worthwhile causes. They need good publicity and therefore pressure scientists to provide it. These councils thus link the scientific community to the social context of these scientific fields. Rip showed how research councils and laboratories are mutually dependent in their struggles to obtain financial backing (which Rip terms 'fundability').

Rip also pointed out that, if in the past, justifications for public funding were grounded in promises of new scientific products, over the last few decades applicants must now provide criteria to judge the social relevance of the proposed projects. The credibility of programmes and public research agencies depends on the relevance of the projects in their research portfolio. Researchers and public research operators are thus forced into what Rip calls the 'struggle for relevance'. In another article, Rip and Nederhof[8] also show how public research programmes and researchers alike adjust their projects to mobilize one another. They also discuss how public operators are led to adapt their policies or research to align themselves with the scientific community, and how researchers refocus their projects to suit the strategy of public authorities. Researchers and public research operators are thus opportunity structures. If they exploit them, the actors can shift the balance between the various opportunities before them. Lastly, Rip extended his analysis to relations between the world of research and the media or public at large. He noted that other battles were waged at this level, the 'struggle for legitimacy' of scientific research itself.

Three Mobilization Modes in the European Programme for AIDS Research

The EC Commission's (CEC's) Medical and Public Health Research Programme is involved in mobilizing the scientific community by creating networks around projects ('concerted actions'). Some 120 networks have been set up in which more than 3500 teams participate. Twenty-nine of these networks have arisen from subprogrammes on AIDS.

Where do these projects come from? Who initiates them? How were they transformed into networks for scientific coordination? Analysis of programme documents and interviews with project leaders have brought out three main mobilization modes. In the first case, the impetus comes from the working party (the subprogramme's management committee composed of two representatives from each member state). In the second case, the programme leaves the initiative to scientists answering a call for tender. If several complementary replies are received, the programme encourages the scientists to work closely together. In the third case, the programme leaves the initiative to scientists answering a call for tender, then selects the projects when they are already 'complete units'.

In the case of AIDS, the working party set up four management subgroups: Basic

Research, Vaccine against AIDS, Treatment of AIDS, Epidemiology. The working party subgroups initiated most of the projects implemented. Consequently, a prior opinion is often formed in these subgroups as regards a given problem. It is then a matter of finding someone with enough scientific renown in Europe to convince competent teams from several countries to work on the project. The working party members therefore play a crucial role in the choice of project leader. Sometimes the working party member most interested in the project becomes its leader.

Once the initiator is found, it is up to this person to formulate a proposal for concerted action and organize its preparation. Most often the initiator contacts two to five colleagues and writes the proposal. After discussion and approval by the working party subgroup, the proposal becomes the basis of a 'preliminary meeting' financed by the Commission. Some 30 research teams from a range of EC member states are invited; most are contacted by the working party members, who provide the names of teams active in their countries. The presumed project leader and his/her team are responsible for meeting preparation. In addition to the written proposal, they must also prepare a draft on work methods and organization to be discussed at this first meeting. The meeting can have several different outcomes. To begin with, research teams manifest their interest in working on the project. Secondly, the future project management group is formed (the working party often imposes geographical coverage) and the teams confirm the choice of project leader (the meeting rarely decides to choose someone other than the presumed project leader). Thirdly, the project itself is discussed, which often leads to a compromise, to be drafted by the project leader. (These compromises often entail additional related subprojects in order to mobilize a sufficient number of teams and obtain the desired geographical coverage.) Lastly, this meeting usually results in a report, published in book form, to ensure visibility beyond the network.

These 'preliminary workshops' make significant headway in forming networks for scientific cooperation: a project leader is recognized; research teams manifest their interest in the theme to be discussed; and the first steps are defined. Most of the ingredients for a concerted action network are already in place. Until recently, the working party's initiative went beyond this step: 'in the beginning research teams and themes were imposed by Brussels; now all I need to do is give them a list of participants for their approval', says one project leader, underlining the working party's direct involvement in the life of a concerted action network.

In the second mode, mobilization passes through the call-for-tender process, whereby the Commission addresses the European scientific and medical community at large. The working party has a different function in this case. It is no longer the initiator, this is 'in the hands of the tenderers'. Two complementary situations can arise depending on the nature of the replies obtained: either the tenderer offers a 'complete unit' covering the range of translations[9] and defines its process (third mode), or the tenderer merely expresses interest (statements of interest) and proposes his/her services along with a pre-draft (second mode).

In the second case, the statement generally centres on the issue/goal translation: 'this issue is very important because ...; this is what we are doing and what we know about the subject; progress can be made by ...'. In a way the ball is back in the working party's court who then identify potential project leaders and once again launch the mechanism of 'preliminary workshops' assembling all tenderers interested in the same theme. The second type of reply is selected only if no proposal from already established networks is forthcoming. Like the first mode, this is a situation of exploration and creation of new networks. Several project leaders have stressed the active role of working parties:

choosing themes that have not been explored in Europe or even internationally, and creating cooperation networks where there were only local initiatives.

The third mode, where the working party receives a complete offer, is a totally different situation. In this case, analyses of 'peer reviews' of projects have shown that academic quality often wins out over thematic originality. It is hard to convince people to take risks, all the more because so many projects are submitted and those finally selected must win out over a large number of applicants. This was partly the case for the MHR programme. Furthermore, on the question of thematic coverage, our investigations into shared-cost R&D programmes[10] demonstrated the importance of defining the call for tender, and its capacity to state clearly priorities in accordance with the budget available, although unfortunately this is rarely the case. This situation generally leads to programmes that ensure a conservative thematic coverage, i.e. they tend to reflect faithfully the orientations of the community solicited. Any original approach thus depends on the initiative of programme officials and direct contacts made with teams. For the MHR management group, this possibility was limited due to its small size.

Because of this situation the programme must select projects proposed by networks that already exist. These are semi-operational or latent networks that chiefly arose from previous interventions by other international organization, the WHO for instance. In these cases, some of the preliminary work has already been accomplished; potential project leaders have been identified (often specialists already responsible for specialized groups), it is known which teams are active in the field, and the interest centres and collective issues have already been defined. The concerted action proposal to the MHR programme is thus of a different nature: it is no longer a question of exploring potential collective action in a new field, but one of defining a targeted 'scientific and technical activity' with a clearly delimited objective, explicit final results, known participants, and predetermined work programme. Thus circumscribed, the activity fits into the new financial constraints set by the programme, which is budgetary commitment limited to a 2-year period.

Methods for recruiting project leaders and initiating projects were significantly changed when the call for tender procedure was introduced. The working party has nevertheless not abandoned its initiative. Most project leaders even feel that without this impetus they would not have applied for project funding or elaborated a project because they did not even know the programme existed. The working party again acts as the initiator, inciting teams to work together, primarily through the preliminary workshops, called to verify that the proposal is well founded and will solicit interest.

In the first two mobilization modes (initiative with the public body and initiative with the tenderer while the public body encourages researchers to work together), networks were originally formed around a small number of teams (3–6). The teams often know each other already; in some cases, the project's promoter associates several foreign colleagues that he/she has already worked with; in other cases, a small, usually informal, network already exists. In the third case (initiative completely with the tenderer), the networks either are almost completely operational or can be rapidly activated. In all three modes, the teams prepare the project at informal meetings or on the phone. With the second and third mode, small assemblies with the initiating terms have already taken place and a statement of interest prepared. After the statement of interest, meetings of experts are occasionally organized where a few additional experts are invited to evaluate and consolidate the project.

The next step is a preliminary workshop attended by a large number of teams potentially interested in the project. The aim is to establish a consensus on the project so as to mobilize interest. At the workshop the project is presented, clarified by

contributions on the state-of-the-art, etc; discussed and then redrafted. The workshop often becomes a scientific colloquium of sorts on the project's theme and is seen as a result in itself: assembling teams who, up to then, had not had the occasion to organize a scientific event on the theme. The assembly is often much more than an extension of the initial core group, because when the Commission has received several statements of interest on related subjects (second mode), the programme managers invite the tenderers to get together to prepare a common meeting that should normally lead to a single common project. This assembly is occasionally a bit forced; in some cases the project's preparation is more akin to a transaction process between subgroups that are already more or less established.

The assembly phase usually ends with this preliminary workshop. The project leader then merely activates the network formed at the workshop. This does not happen with projects, however. For some, active recruitment begins at the start of the concerted action. This is the case, for instance, with certain centralized facilities (such as sequencing the HIV virus, screening anti-viral molecules, or experiments on chimpanzees). The same generally holds for networks where a large number of local teams must be recruited to collect data in order to implement a protocol (for example when evaluating the treatment of opportunistic diseases). In some concerted actions the assembly phase ends with the selection of teams: evaluating the quality of the teams and conditions for participation.

Three modes for mobilizing the scientific and medical community were thus found in the framework of the MHR programme. In the first, the public research body takes the initiative and then attempts to find allies entrusted to form a network around a project to be defined in common. The public body launches actions in fields it sees as priorities. In the third case, the initiative lies completely with the tenderer and the public body limits its intervention to deciding whether to retain the project or not. The public body accompanies and activates the action of international institutes and scientific or professional societies that already exist at a European level. Between these two extremes, there is a mode with alternating initiative: calls for tender where the tenderer takes the lead and the public body intervenes to support and draw decentralized or individual initiatives closer together.

Coordination of Scientific Work

After describing how a public research body succeeds in mobilizing and assembling researchers and doctors, the next step is to analyze how the latter coordinate their activities. Our second investigation thus revolves around coordination modes.

Although the early works of sociologists of science analyzed the aggregation of individual scientific practices in terms of communication systems and regulation through values and norms, this concept is no longer feasible in the light of the most recent analyses. There is such a wide diversity in practices and such a continuous redefinition of actors that it is not possible to regulate them through general norms. Organizational sociology has proposed various analyses which take into account formal structures and margins of uncertainty for example. This work, however, is of little use to us; in scientific practices there is such a wide redistribution of roles and actors that the concepts suggested by organizational sociology do not fit. Scientific actors often work in significant conditions of uncertainty. And in order to attain a certain balance, there must be a minimum of predictability in the behavior of actors.[11] We shall attempt to use the notion of 'forms of coordination' to account for processes of aggregating individual actions that are not reduced to norms, organizational rules or markets. As the sociology of science has

established the double constitution of scientific activity, i.e. its local roots and the delocalization of its products, it is thus a matter of looking into the concrete mechanisms that make this delocalization possible—how local becomes universal—and the aggregation of local practices.

For this, the notion of 'Networking' is useful. Its first meaning, taken from the sociology of social networks,[12] designates a set of individuals linked by the flow of information they exchange, by contacts they maintain, or by the fact that they mention one another. The network is formed by a group of interlinked points, each point being a scientist. Indicators are proposed for these sets of relations, especially the density of relations. When a group of individuals presents a fairly high density of relations locally, it can be isolated and seen as a group. The members of this group do not necessarily share common characteristics, as would be the case for logical classes such as professional fields or specialities. One advantage of the networking concept is that it enables us to redefine the concept of scientific community, to elucidate subsets where relations are slack and dispersed, and to follow transformations in scientific groups (emergence, extension, fusion, scission, budding, recession, dissolution, etc.).

The above networking concept solely concerns relations among scientists. Several works,[13] however, have shown that social networks in science are heterogeneous; that is, they are composed of scientists from various fields and non-scientists. With this extended concept of social networking, social structures must be seen as sets of links between cores where rare resources are concentrated. The actors establish these links to have access to other actors' resources. The nature of the resources and the actors, however, is not an *a priori*, but is defined by the very interaction of the actors. Interaction is not merely the exchange of goods or information; it is a constitutive relationship, a translation relation through which the cores as well as the nature and form of the interaction are mutually defined.[14]

Lastly, through the principle of generalized symmetry[15] and by applying the same terms to humans and non-humans, the networks become sets of entities (not necessarily human) linked by translation relations during which they are mutually defined: actor networks or socio-technical networks. The object of the analysis thus becomes these networks themselves and their transformations, whether it is a question of monitoring production and diffusion of a scientific or technical finding, analyzing a scientific policy, studying the life of a scientific community, or evaluating a field of research. This new concept stresses the combinability of material and immaterial elements. It allows for major shifts by transcending a strictly local analysis and disturbing a series of preconceived distinctions between cognitive and social, material and immaterial, human and non-human, content and context. It also has the advantage of allowing the observer to analyze the production of coordination forms in their diversity, and in their dynamics. In relation to our investigation into methods for coordinating public responses to AIDS, this approach enables us to demonstrate that the socio-technical networks are not integrated by common characteristics shared by the agents (logical classes) but by what is transmitted among agents in their interaction. The next logical step, therefore, is to investigate what links the actors and what circulates among them.

Networks and Circulating Intermediaries

Networks are integrated through intermediaries exchanged between actors. These transmitted intermediaries describe and define the networks. They result in and constitute the mutual definition of actors. They are thus mouthpieces/spokespeople and mediators which, when they are mobilized, mobilize in turn the diversified sets they

represent. They can be grouped into several categories:[16] skills, instruments, materials, documents, and funding credits.

Tacit or explicit skills: these are scientific, technical and organizational know-how embodied in individuals. These skills can evolve in time when people are displaced but also with the gradual elaboration and incorporation of new skills in the course of the work itself. When the analysis follows people, research fora appear to be more extended than they originally seemed to be; they are taken up in networks of industry, administrators and laboratories that define research programmes and evaluate results. Scientists form invisible colleges, participate in working groups and maintain numerous individual relationships. They mobilize outside collaborators, investigators, suppliers of reagents and laboratory materials. Recruiting a researcher, for example, means mobilizing a spokesperson; the voice of a network formed of all the entities to which he/she is attached and in whose names he/she acts, whether this is a field that is already constituted or emerging, or else all that is said, written and done with a new type of equipment. If, instead of recruiting a new researcher, a 'representative' of industry or administration is to be associated to a working group, the group actually seeks, through this person, to mobilize the whole organization that he/she represents. The networks of these new recruits can be more or less extended or restricted.

Instruments: these make up a laboratory's infrastructure. Instruments are also embodied know-how and mouthpieces. Instruments are associated with specifications[17] that determine a zone of usage that can be extended or reinterpreted by their users. Instruments give voice to the people who designed, manufactured and transformed them. They are usually associated with texts (such as instruction manuals), other machines (such as those that can be connected to them) and people (such as demonstrators, repair staff, experienced users). Like any mouthpiece, they can be denied, negotiated or sent back.

Materials: these are reagents, products, materials, specimens and samples (the latter being more or less weak mouthpieces for the populations they represent). Oudshoorn[18] has shown, for example, how the accessibility of research material (urine and the sexual hormones it contains) affects not only the social organization of the research, but the development of a research field and its cognitive orientations as well.

Documents: these take the form of articles, reports, laboratory notes, research proposals, questionnaires, theses, patents, reference books, order forms, etc. Researchers thus appear as readers and writers; without literature they would not know what they can rely on and what is worthwhile to do. Through documents, researchers keep in touch with other scientists, nearby or far away, and with people interested in their work (clients, educators). Texts thus represent humans (authors, potential users defined in the text itself). Articles, for example, are authorized expressions, legitimate mouthpieces, of what the entities represented in the text want to do or are doing. The same holds for diagrams and any type of sketch (signals, photos, listings).

Funding credits: these may come from administrations, industry or foundations. Money has a double significance: it measures the donor's degree of support and qualifies what he/she wants exactly or thinks he/she wants. Money always conveys a message; it is also the mouthpiece of a network. Money is also a resource that makes it possible to procure other mouthpieces. But, it is also the mouthpiece of the donor, and is generally associated with restrictions and pre-established attributions.

The intermediaries that circulate among actors describe and accomplish the networks' articulation and integration. They partially illustrate a scientific response's capacity to

convince and impose itself. Intermediaries are mobilized to build facts, knowledge and techniques, and to provide fora for their circulation.

Scientific products, however, never achieve their full capacity. They are ceaselessly recreated through multiple negotiations and interactions, which correspond to changes in knowledge and technological innovations. The variety of actors interacting occasionally form coordinated sets which we call 'scientific cooperation networks'. These networks are not only composed of actors; they also include the multiple intermediaries that unite and give their matter and form to relations. It is important to remember this when describing the characteristics of scientific cooperation networks set up to address the problem of AIDS.

The Growth in Scientific Cooperation Networks

Since the 1960s, new forms for organizing scientific work have arisen. Networking, which was once a local and informal affair, has become a voluntary and collective enterprise. There is now a political will to organize scientific work by establishing public research programmes. Interventions of the EC Commission typify the growth of these new scientific policies. With these new policies, scientific work moves from an articulation by researchers with their specialist institutions, scientific societies and professional journals, to an organization of the conditions in which it is carried out. Scientific cooperation networks have emerged in this context. The managers of public research programmes increasingly foster cooperation and networking between research bodies. For instance, in the case of the Commission's third non-nuclear energy programme, 68% of European funding concerned multi-partner commitments. Projects associating teams from at least two member states represent 60% of the subsidies. A typical project in this programme could be centred on the development of new technologies and include two universities (German and British, for example) as well as a French technical research centre, a large Italian firm, and one or two small/medium enterprises from a smaller country.[19] Another example is a Commission research programme which affects the scientific and technical fabric of member states. A major impact of European programme for France has been to initiate and foster new forms of cooperation.[20] Researchers are linked with an average of three new partners and intend to pursue this collaboration beyond the project. Networking is, moreover, more important for technological programmes than for programmes on academic or societal research.

AIDS Scientific Cooperation Networks: Characterization

The MHR programme of the CCE is entirely dedicated to building scientific cooperation networks. More than 3500 teams are working in some 120 networks, 29 of them on AIDS. They can be analyzed on the basis of the following six criteria:[21] finalities (issue, goal, objective), results (interim and final), actors mobilized, circulating and non-circulating intermediaries, organizational forms.

When the finalities are understood, to a certain extent, it is possible to realize how certain specific forms of scientific cooperation are used. Scientific cooperation networks on AIDS are necessary complements to laboratories. This can be the case when the enormity of the effort required or the complexity of the problem calls for either an extended coverage (geographical: to study the virus's genomic variability or to monitor the epidemic's progress; scientific: interdisciplinary study of interactions between the virus and membrane wall; technological: harmonizing serological methods) or a synergy of efforts, resources and skills. The issue common to all the subprogramme networks is

the fight against AIDS. It is nevertheless translated by different goals depending on the network. There are three types: AIDS prevention; protecting the population with vaccine; and treating the disease. These finalities are themselves translated by four types of final result: monitoring networks (the epidemic as a whole or specific subgroups); evaluating medical treatment (especially opportunistic diseases); harmonizing practices (for example, serological tests or dental treatment practice); and structuring scientific communities (especially discussion fora and networks built around centralized facilities).

The analysis of circulating intermediaries brings out the importance of their design, use, circulation, assembly, processing and conservation. Their circulation describes the network and the project's ongoing processes. For instance, with answer forms, reference material and samples, the observations on and description of local phenomena or objects become delocalized, compared and combined to construct new knowledge. They call for the production of calibrating instruments, harmonization of data-collecting conditions, organization of their circulation and conservation. Sometimes equipment must be exchanged or skills incorporated when practices are harmonized.

Actors in some projects, particularly in centralized facilities, must develop non-circulating intermediaries (NCIs). These NCIs are not only heavy equipment; they are also sets of equipment and skills found at a local site (a laboratory for example) that pursues its own research objectives through the 'services' it renders. We have observed two types of non-circulating intermediaries: common internal services (*ad hoc* databases and centralized facilities handling samples, and data harmonizing the analyses); and orientation NCIs (a single service offered to researchers, focalization of themes, and harmonization of scientific practices, accumulating a specific body of knowledge on one site).

Projects mostly combine several types of exchange. The combination not only defines the extent of the effort made by the teams to communicate among themselves; it also makes it possible to measure the extent of their involvement. An analysis of the mixture of circulating and non-circulating intermediaries led us to classify networks into four different groups:

Classical exchanges: the teams are involved only in classical activities such as colloquiums and meetings between researchers. In some cases the teams have extra financing for additional one-off exchanges.

Exchanges harmonizing research practices: meetings and visits are broken into thematic subgroups intent on obtaining a consensus (developing protocols). This harmonization effort often leads teams to exchange materials: samples or reference materials. This group of projects enters in a given phase of the typical dynamics of the networks studied: harmonization of viewpoints and research practices. Most of the projects devoted to creating specialized scientific communities come under this heading.

Data-collecting structures: this involves centralizing local data through the implementation of protocols and circulation of literature. The primary exchange media is paper (questionnaires sent out and returned, treatment protocols, monitoring forms), and these projects often develop large databases. Monitoring networks often come under this intermediary mixture group.

Heavy logistics exchanges: in the networks of this group, research practices and exchanges are linked to the existence of non-circulating intermediaries that condition processes and their success. These projects differ from the above groups in the heavy logistical or technical investment needed to analyze or circulate samples. Some create data-collecting structures centred on the collection and assembly of samples, and are often associated

with large databases or sample banks. Others, such as analysis laboratories or testing centres, are organized around orientating NCIs.

The networks are organized in a small number (5) of modes: the forum; laboratory without walls; starred network; geographically partitioned network; and the thematically partitioned network. These models are not always stable throughout time; they can be transformed with progression from one step in the dynamics to another (for example, a laboratory without walls linked to creation of a protocol can become a starred network when the protocol is implemented). There is also a close link between the type of actors mobilized and organizational forms.

AIDS Scientific Cooperation Networks: Four Coordination Modes

Relationships can be drawn between the various characteristics of the networks analyzed. It is possible to establish four major modes for coordinating 'scientific' responses to the problem of AIDS.

With networks having a 'data collection structure', coordination often entails managing the circulation of papers and compiling large databases. They articulate teams of data suppliers and the laboratories that process, maintain and make use of the data. The network is generally subdivided either by region or by theme, and serves to monitor a phenomenon, primarily epidemiological, to harmonize practices, or to evaluate treatments. Some networks live beyond their specific task to be instituted in the form of services. In this case, the network is an instrument of coordination that can mobilize a large number of local actors who, after due preparation, can emit immutable mobiles, which are gathered, placed in parallel, compared and conserved in a limited number of places. The 'data collection structure' network is a form of coordination dedicated to what Latour terms 'worlds mobilization'; it manages 'collection cycles' and enables local knowledge to become universal knowledge.

The 'forum' type of network is an organization form typically based on 'classic' exchanges between teams: meetings. Its specific result is to initiate new local or collective projects. The network structures a scientific community around questions of research, objects of study, methodologies or development of new products. This type of network is set up to organize small specialized communities (information circulation) and to explore problems that straddle the borders of distinct disciplines. The 'forum' network most closely resembles what sociologists of science have generally analyzed: communication systems, paradigmatic communities, formation of social scientific networks.

The network type 'thematic partition with harmonization of research practices' is the 'hard network' version of the forum. It is characterized by a mixture of circulating intermediaries (data, samples, reference materials, etc.) and non-circulating intermediaries (reference laboratories and centralized facilities). It most often takes the form of a thematically partitioned network, dedicated to structuring a scientific community or developing new products. This type of network is an action system that aligns teams and entails mutual comparison of their production. It is a particularly constraining coordination tool; the cost of aligning actors is such that a clear distinction is gradually formed between network members and those on the outside. In the network, local scientific production can be circulated easily, and rapidly transformed into universal scientific products. Outside the network, however, scientific productions are condemned to remain local. The network represents a greater forum for universalization than the laboratory, and is largely founded in equivalence systems that it sets up, which lend predictability to

the behaviour of its actors. A necessary component of this type of network is a vast socio-technical arrangement of laboratories.

The network type 'starred around a central facility' is another type of hard network, revolving around a centralized facility (reference laboratory, testing centre, etc.) with which material exchanges take place. It has the form of a star as most teams are not necessarily based in the centralized facility. This type of network is always dedicated to structuring a scientific community. The non-circulating intermediary tends to orientate problem formulations and harmonize practices. Subgroups responsible for managing access to the centralized facilities often produce sets of standards that are specific to the network.

Some Properties of Scientific Cooperation Networks

From our analysis of modes for scientific coordination in response to AIDS, we can draw the following conclusions:

- Scientific cooperation networks are heterogeneous. Their members are not only researchers; there are also a large number of various types of practitioners, industrial laboratories, public health operators. Their members differ in terms of institution type, discipline, role and involvement. Networks are thus primarily arrangements of heterogeneous entities or actors.
- Scientific cooperation networks are flexible ways to respond to the problem of AIDS. Whether they are data collection structures, partitioned networks with harmonized research practices, or networks starred around centralized facilities, one overall characteristic is that they are not set institutions. Quite the contrary, not only are they part of a defined time period, they are also, and primarily, flexible arrangements. Their composition varies with the work's evolution, temporarily associating dispersed entities. Even if some types of network appear more stable and constant, the fact that they are primarily formed around projects leads them to be seen as transitory and basically flexible forms of cooperation. They are *ad hoc* arrangements appropriate to the projects that governed their formation. Some networks intend to continue in a relatively stable manner—this is the case for some networks starred around centralized facilities, some forums, some data collection structures that can be applied to new studies. But even if these networks function beyond the mere framework of European public financing, they are neither instituted nor recognized (at least not yet) institutionally. In the short term, they are fated to be at least reorganized.
- Scientific cooperation networks arise from the equivalence established among actors. This enables dispersed resources to be delocalized and acquire the weight of the network they describe. Flexible cooperation networks generally do not construct new, heavy and localized entities but a series of hardly visible links whose main result is to establish grounds for equivalence whereby a series of behaviours becomes predictable and actors can spare themselves a certain amount of negotiation (not everything needs to be negotiated). At the end of the life of a flexible cooperation network, what remains is a latent network, a series of connections that can be reactivated easily in the form of new local cooperation or a new network for flexible coordination.
- Lastly, the scientific cooperation network creates irreversible situations. While they produce interim results, the actors gradually consolidate their networks and create time indicators. The interim results represent the progressive agreement reached among the teams and refer to the links they developed to obtain this result

(structuration effect) and the common references they developed in order to work together (effect of aligning language and experimental practices). The interim results then serve to promote the network's extension and consolidation. The problem is the same for the transfer of the final results (a monitoring service for example). The final result must be seen as the convergence of one-off networks. Through these results, scientific coordination moves on to the level of medical practices and health policy.

Coordination Responses to AIDS: Taking Results into Account

We have shown that scientific cooperation networks are heterogeneous in their make-up and flexible in their dynamics. They create irreversible situations and systems of equivalence in a way that singular actions arise from collective equilibria. These properties seem especially appropriate when considering a complex problem where it is not yet possible to describe the steps towards a solution, nor define the solution to be obtained. In such a system, it is crucial to connect actors, to enable translations among one another, thus ensuring the circulation of problemizations, suggested solutions, information and local production. Here it is a matter of creating a forum for circulation where the least important new finding can be applied rapidly, evaluated, adapted and developed by others. The solidity of solutions proposed to the problem of AIDS largely depends on the consistency of the networks created.

Networking, nonetheless, is not an easy operation. Considerable investments are needed to make singular scientific productions delocalizable. Networking, therefore, cannot be reduced to social relationships between scientists who exchange ideas and discuss results. Various intermediaries must be circulated; their details determine both the form of the network and the dynamics of its projects. It may take from 2 to 10 years to progress from assembly of the teams to transfer of final results. The duration of the process depends on the network's initial state, the duration being shorter for latent networks activated through European financing. In this case, the actors are already mobilized, speak the same language, work on similar equipment, have equivalent work methods, and develop common questioning. The orientation of their work is often similar even if they had not worked together for a while. In other cases, however, the network's biggest task is to create and use equivalences between teams by building the tools, language and common questioning. This work often takes several years; it also takes time to design, develop and circulate multiple intermediaries.

Network building thus partly depends on coordinating objects. And this coordination cannot be reduced to organizational rules, nor to a set of common norms—even though networks also produce their own norms on work sharing, appropriating results and the right to represent the network. Coordination also entails translation/articulation efforts and implementation of socio-technical objects and instruments.

A non-circulating intermediary can thus polarize the activities of the teams towards a common goal. This is the case when a single work tool is used by several teams of researchers (for example, to obtain original material, or to carry out an experiment that would otherwise be inaccessible). Such a work tool does not constitute just heavy equipment; it may also constitute the knowledge and skills accumulated and incorporated in researchers, in procedures, in a laboratory organization and in publications. Through their collection and local articulation, a particular entity can function as an obligatory point of passage. This type of intermediary enables teams to attain their objectives more easily and surely; but these objectives are continually translated and orientated. By focusing works on certain themes or approaches, by eliciting and imposing modifications or harmonizations in research practices, the intermediary socio-technical instrument

affects the dynamics and orientations of a whole set of laboratories at the same time it reinforces its position as obligatory passage through new accumulation of knowledge, know-how and materials. If an instrument imposes itself as an intermediary between researchers, this is due more to its accumulated skill and experience than to its unique technical nature. An instrument cannot be simply maintained: its actors must constantly negotiate and find compromises between their own needs and objectives and those of their network partners. Coordination entails progressive enrolment and articulation with the non-circulating intermediary.

In other cases, coordination through a non-circulating intermediary requires the use of an original material (such as costly reagents whose quality is standardized and controlled). The non-circulating intermediary renews the resources it works with, transforming the themes of the research field. The combination of these circulating and non-circulating intermediaries is crucial in organizing and structuring a specialized scientific community. This is the case in the development of an AIDS vaccine.

If we now examine circulating intermediaries, the relevance of coordination among objects is confirmed. The ENTA (European Network for Treatment of AIDS), with its circulation of forms, revealed how such an intermediary can transform practices. It also underlined the importance of other types of coordination needed for this circulation. In fact, it is an almost military-type organization that must foresee all eventualities, prepare each step and its corresponding documents, keeping track of all events and organizing permanent monitoring and verification processes. In this case the network's coordination resembles that of bureaucratic organizations. The circulation of various documents reveals the network: who the actors are and what they do, the gradual compilation of solid results, the network's structure and coordination mode. This example shows the degree to which management of paper gives a scientific project its cohesion, rigour and solidity. The coordination of scientific work depends on these objects.

Conclusions

Using as examples of the projects initiated in the framework of the fourth MHR programme of the EC Commission, we have analyzed the modes of mobilization and coordination used by the research world in their response to problems posed by the HIV virus and the development of AIDS. Three mobilization modes were found: initiative taken by the public operator; initiative taken by scientific actors presenting 'complete' projects; and initiative taken by scientific actors with the public operator fostering links. This confirmed the hypothesis of a reciprocal mobilization of both scientific and political worlds. These actors must take each other into account at the same time they redefine one another. On coordination, four major modes were identified: 'data collection structure' type; 'forum' type; the thematically partitioned network with harmonized research practices; and the network starred around a centralized facility. These scientific cooperation networks are composed of heterogeneous actors; they are flexible in their forms of coordination, producers of irreversible situations and, most importantly, operators of equivalence between actors. Because of this, they are a particularly appropriate response to a problem such as AIDS; they link actors, translate actions among them, and ensure the circulation of the problem's formulations and ideas for its solution. They are both fora and conditions that enable the displacement and desingularization of scientific products. Once these products are applied, evaluated, adapted and developed by ever widening circles of actors, they become solid solutions to the problem of AIDS. These results, however, call for considerable investments. Establishing equivalence among

actors, in particular, calls for the implementation of multiple intermediaries to give both form and consistency to relations and networks.

Building networks for scientific cooperation, however, is just one response among many; and our analysis was restricted to projects in the CCE-DGXII's MHR programme. In research alone, the CCE represents only a small, even if particularly pertinent, portion of the research activities carried out in member states or in other international organizations (scientific societies or institutions such as the WHO). More basically, European scientific cooperation networks cannot exist without laboratories, clinical teams and national or local public financing. The efficiency and flexibility of this coordination mode depend on the ability to rely on stable local points, such as locally financed laboratories.

It would thus be worthwhile to extend the preceding analyses to other modes of mobilization and coordination, to analyze their specificity and relationships. In order to compare practices and dynamics at work, the criteria developed to analyze scientific cooperation networks could be applied elsewhere and their relevance evaluated. Comparative studies should include the following three dimensions: finalities and results (forecasted and actual) of actions; the actors mobilized and organizational forms; intermediaries (circulating and non-circulating) and the networks they build. State responses to AIDS should be compared by contrasting the networks created (especially their dimension and nature). The criteria described above should a *priori* be applicable for actions leading to the production of scientific knowledge and innovative socio-technical instruments, as well as for their dissemination and transformation from one actor to another.

Notes and References

1. Cf the Mertonian sociology of science, for instance: S. Cole & J. Cole, *Social Stratification in Science* (Chicago, University of Chicago Press 1973); W. Hagstrom, *The Scientific Community* (New York, Basic Books, 1965); R. Merton, 'Science and Technology in a Democratic Order,' *Journal of Legal and Political Sciences*, I, 1942, pp. 115–126.
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3. For instance: P. Forman, 'Weimar Culture, Causality, and Quantum Theory, 1918–1927,' *Historical Studies in the Physical Sciences, 3*, 1971, pp. 1–115; D. McKenzie, *Statistics in Britain, 1895–1930. The Social Construction of Scientific Knowledge*, (Edinburgh, Edinburgh University Press, 1981).
4. To qualify these heterogeneous aggregators, Callon introduced the concept of actor-network (M. Callon, J. Law & A. Rip, *Mapping the Dynamics of Science and Technology* London, The MacMillan Press 1986) and Knorr the concept of transepistemic arena (K. Knorr-Cetina, 'Scientific Communities or Transepistemic Arenas of Research? A Critique of Quasi-Economic Models of Science', *Social Studies of Science, 12*, 1982, pp. 101–130).
5. M. Callon, 'Struggles and Negotiations to Define What Is Problematic and What Is Not. The Socio-logic of Translation', in: K. Knorr-Cetina, R. Krohn & R. Whitley (eds.), *The Social Process of Scientific Investigation*. Sociology of the Sciences, IV, Dordrecht; Reidel, 1980), M. Callon & J. Law, 'On Interests and Their transformation: Enrolment and Counter-Enrolment', *Social Studies of Science, 12*, 1982, pp. 615–625; M. Callon, J. Law & A. Rip, *op. cit.*
6. Latour & Woolgar, *op. cit.*, Ref. 3.
7. A. Rip, 'Contextual Transformation in Contemporary Science', in: A. Jamison (ed.) *Keeping Science Straight. A Critical Look at the Assessment of Science and Technology* Gothenburg, Dept. Theory of Science, 1988, pp. 59–850.
8. A. Rip & A. Nederhof, 'Between Dirigism and Laissez-Faire: Effects of Implementing the Science Policy Priority for Biotechnology in the Netherlands,' *Research Policy, 5*, 1985, pp. 253–268.

9. When project leaders prepare concerted action proposals, they define a series of articulations (translations) which allow them to pass from scientific and technical objectives to socio-political goals and vice versa. These translations refer to scientific, social and political choices that are often implicit. They are what enable research to move, for example, from cells to humans, from the laboratory to the clinic, from purification to treatment. In order to identify the translations as they appear in the aims of the projects, we have pinpointed the issues, goals and objectives of each translation: the issue refers to the socio-economic problem to solve (in this case AIDS); the goal manifests the first translation by proposing a way to solve the problem (developing a vaccine, designing health education campaigns, etc) that is meaningful to the research community; and lastly the objective determines scientific and technical choices which come into play (studying HIV/membrane interactions, monitoring a risk population, etc.). The liaisons formed among these different levels of translations are not mandatory; they illustrate strategic choices, especially because they convey a later social organization.
10. In particular, M. Callon, P. Laredo, P. Mauguin & D. Vinck, *Evaluation des programmes publics de recherche, Le cas du programme communautaire Energie Non-Nucléaire* (Presses Universitaires de Namur, 1989).
11. L. Boltanski & L. Thevenot, *Les économies de la grandeur* (Cahiers du centre d'études de l'emploi, no. 31, PUF, Paris, 1987).
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13. M. Callon & J. P. Vignolle, 'Breaking down the Organization: Local Conflicts and Societal Systems of Action', *Social Science Information*, *16*, pp. 147–167; Callon, *op. cit.*, 1980, Ref. 6 Knorr, *op. cit.*, 1982, Ref. 4.
14. Callon, *op. cit.*, 1980, Ref. 6.
15. L. Callon, 'Eléments pour une sociolgie de la traduction. La domestication des coquilles Saint-Jacques et des marins-p; afecheurs dans la baie de Saint-Brieuc,' *L'année, Sociologique*, no. *36*, 1986, pp. 169–208.
16. We shall refer to the categories proposed by M. Callon (ed.), *La Science et ses réseaux. Genèse et circulation des faits scientifiques*, (La Découverte, Paris, 1989), to which we have added the category of materials.
17. M. Akrich, 'Comment décrire les objets techniques', *Techniques et culture*, *5*, 1987, pp. 49–63; M. Akrich, 'L'analyse socio-technique,' in: D. Vinck, *La gestion de la recherche, Nouveaux problèmes, Nouveaux outils*, Brussels, De Boeck, (ed.) 1991; J. Johnson (alias B. Latour), 'Mixing Humans and Nonhumans Together: The Sociology of a Door-Closer,' *Social Problems*, *35*, 1988.
18. N. Oudshoorn, 'On the Making of Sex Hormones: Research Materials and the Production of Knowledge,' *Social Studies of Science*, *20*, 1990, pp. 5–33.
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20. P. Laredo, M. Callon, *L'impact des programmes communautaires sur le tissu scientifique et technique français* (Paris, La Documentation Française, 1990).
21. P. Laredo, R. Akehurst, N. Bradshaw, B. Kahane, P. Laredo, J. B. Meyer & E. Sutcliffe, '*How to Characterize Networking Activities in Public R&D Programmes?*' paper presented at the 'Policies and Publics for Science and Technology' EAST Conference, London, 7–11 April 1990; D. Vinck & P. Laredo, 'Characterizing Concerted Actions and their Dynamics,' in P. Laredo, B. Kahane, J.-B. Meyer & D. Vinck (eds.) *The Research Networks Built through the MHR4 Programme* (Publication Office for CEC, Evaluation Report, 1991).