The New Production of Particularism in Models relating to Research Policy. A critique of Mode 2 and Triple Helix

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In the aftermath of the Second World War the growth of science became a recognized policy objective. The *Frascati Manual* that was developed by OECD ministers of science and higher education in order to keep tabs on and compare funding flows to science in different countries recognized three categories for accounting: basic research, applied research and product development (R&D). [1] Encoded in the first science policy doctrine in the early 1960s the definitions of these different types of activity gelled a mind-set, norms and criteria. Basic research was regarded as purely curiosity-oriented and free from attempts to steer it, while applied research and technological development were necessarily subject to external determination, market demands or social policy objectives, later denoted as "sectorial", e.g., defense, energy supplies, housing programs, health care, and so on.

Simplifying greatly one can say the first OECD science policy doctrine is characterized by science-push GNP growth. This was followed by a second doctrine in the 1970s, distinguished by a belief in market or societal pull and sectoral steering (with a lot of "science for policy" but not so much "policy for science"); the third OECD doctrine, associated with the 1980s was an orchestration policy with a partial focus on basic research to stimulate new and emerging technologies; and in the 1990s, under the impact of macro-economic globalization as well calls to sustainable development, a popular phrase became, "towards a new social contract for science". [2]

From the outset the definitions were normative, and so were the statistical householding procedures. The very definition of "innovation" is therefore contextually contingent, changing over time; in each period specific social epistemologies and historical background conditions influence the emergence and workings of different modes of boundary maintenance between science and politics.

By the late 1980s, and especially with the end of the Cold War and the collapse of the former Soviet Union, the boundaries and distinctions as originally conceived were no longer self-evident, and several attempts have been made to redefine what in retrospect has been called the new "social contract for science". [3] The American science adviser Vannevar Bush, author of an influential report, *Science - The Endless Frontier* (1945) is often credited with drafting the blueprint for the traditional social contract for science that undergirded OECD's first science policy doctrine, but actually he never used the term "social contract.[4] It is a retrospective construction in a quest in the 1980s to shape a *reconfiguration*, one that in the eyes of many researchers has narrowed the confines of academic freedom and autonomy, while giving freer play to commodification of research and commercial stakeholder interests (market governance) and other players, including social movements and activists or NGOs.

A number of terms have been introduced to try to capture characteristical features of the "new" situation in order to contrast these with the "old" image(s) of science. The most frequently cited notions are:

- mandated science (Salter)
- postacademic science (Ziman)
- Mode-2 science (Gibbons et al.)

- Triple Helix (Etzkowitz and Leydesdorff)
- academic capitalism (Slaughter and Leslie).
- post-normal science (Funtowicz and Ravetz)
- socially robust science, or science in the *agora* (Nowotny et al.)

In addition the term postmodern is sometimes taken over to refer to the new situation[5], and occasionally reference is made to an image of nomadic knowledge production.

The much debated book *The New Production of Knowledge* (1994) [6] is only one of many pertinent publications. The former Swedish Council for Planning and Coordination of Research (FRN) sponsored the work behind it. Three of the authors, in light of the debates generated, have since then come out with a sequel, *Re-Thinking Science. Knowledge and the Public in an Age of Uncertainty* (2001). [7]

The present paper briefly reviews some of the detail regarding changes in the academic research landscape and its context that have prompted a re-thinking of research policy models. The post-World War II situation will be highlighted, but concentration is on the past forty years. Thereupon follows presentation and discussion of a number of the different theories or models of "new production of knowledge" that have emerged during the last couple of decades. In a third section of the paper some points of criticism are directed to these new models. It is argued that in the same way as the linear model of innovation in its day, they provide the ingredients in a new and powerful thought figure. In important respects this is also one-eyed and reductionist, since they focus mainly on a relatively small - albeit significant and dramatically changing - domain of the vast and diverse landscape of science in society. The term "reductionism" in the title of this chapter is meant to convey the sense not only of partiality of new models but also their tendency of over-simplification to a single dimension or set or phenomena, roughly 1/20th of the pertinent landscape.

Finally the paper points to further facets in the new conditions of research, ones that have hitherto received less attention.

The changing landscape

Internationalization and globalization

There is a definite increase of cross-boundary partnerships. Cumulation of interconnectivities and more intense communicative interactions or even collaborations make up patterns that are however skewed by global inequities, primarily between the North and the South. This implies new and greater divides between haves and have-nots, mechanisms of inclusion/exclusion. It is in this context one should see the recent proliferation of partnering, bilateral between major universities and centers, and multilaterally in network organizations and multinational funding programs, supported by national strategic programs. Today competition between the world's three great trading blocks is an active ingredient of socalled globalization, which is increasingly providing a frame for emerging science and technology.[8]

International collaboration is frequently motivated by the need to cut costs, tap into competence and gain intelligence across borders. Companies seek knowledge where they can best access the research they require; adult education and retraining programs for firms are frequently handled by consultancies but universities are now also making inroads in this branch.

In addition of course some major international research programmes are politically motivated by the simple fact that several urgent problems facing us cut across national boundaries.[9] Environmental degradation, the loss of biodiversity and global climate change are examples of this.

In OECD circles large scale projects or efforts needing intergovernmental cooperation, billions of dollars in funding and new forms of management have come to be called Megascience. Big Science was characterized by team work, large scale funding, more formal contractual relationships between the state and academe, and the industrialization of modes of research management.[10] Megascience (involving high-level inter-state diplomacy) takes this one step further, either in the form of concentrated efforts in one place, as in the case of CERN, or in distributive fashion, as in the Human Genome project.[11] Parallel to this there is a proliferation of bilateral agreements between universities in different parts of the world. These agreements are used to enhance the competence and stature of the agreeing parties, which in practice means competition with and exclusion of others on a global arena. In this way industrial modes of behaviour are further replicated in certain (but far from all) realms of science.

Collaboratories encapsulate the idea that promising new areas of R&D can be developed through networking, linking public institutions, local academic units, companies and groups, with calls for greater mobility of advanced knowledge and of those who possess it.

External funding and proprietary research

New types of funding agencies have been introduced across the map, and in Sweden for example recent organizational concentration has been the target of much criticism from the side of academe. Foresight exercises in many countries are used to generate broad lists of priorities, and agencies get geared to funding earmarked areas of strategic significance for long term economic competitivity on a global market, as well as societal welfare in a broader sense. New areas like genomics and bioinformatics have also emerged, often designating multidisciplinary centers working at armslength from industry. Centers of excellence is another key word, some would say, a buzzword. In some instances hype is finding itself into the texts of research grant applications. Packaging, visibility and eye-catching logos meant to signal efficiency and credibility have become the object of wrangling. EC funding, though still limited in volume, has made inroads with certain steering effects. At the same time in some policy documents the notion of grooming "Industrial Hollywoods" to make regions attractive sites for international partnerships. Overall the old Cold War rationale of national security has been replaced by the rhetoric of economic competitiveness. Issues of proprietary research and intellectual property have gained prominence.[12]

In the US the ratio of public funding of scientific research to private funding is today 1/3 government funding and 2/3 private funding, a reversal of the proportions that obtained after World War II.[13] This changing structure of scientific funding is occurring more slowly in Europe, but it is happening. In Sweden, for example faculty funding at universities in the beginning of the 1990s was 60%, today it comprises 40%. [14] An entrepreneurial flavor also permeates images of new role models and management schemes within academe. Knowledge societies are becoming knowledge control societies, as research gets increasingly steered by patents and licensing arrangements.[15] For parts of academe the shift implies greater steering from the outside with an eye on economic productivity, together with sharper competition for external funding and a constant situation of under-financing at our universities. Short-term projects gain favour at the cost of long-term continuity and greater vulnerability to the ups and downs of the stock market.

Still some large corporations like to have a division of labor where universities should continue to be the home of fundamental research, while reconfigurations of added value knowledge takes place in consultancies or other sites under their hegemony. Long term agreements with universities for first option of refusal for patenting novel findings are not uncommon. Here the vocabulary setting out the contractual relations becomes vitally important, and universities are becoming more adept at honing their skills to meet this demand. In Sweden, for example, university holding companies, which however have been losing money, is a new feature on the horizon. Still, unlike the situation in the U.S., patent revenue has not yet been taken as a measure of universities' prowess. Here the European universities still reflect a different tradition as civil service institutions under the legal rule of the state, although this status has also been loosened up over the past couple of decades. As in the U.S. there are also voices cautioning academe to stay away from the bandwagon of extreme entrepreneurialism. Uncertainty of economic payoff from investment in research prevails, and the possibility of measuring the economic impact of research is highly contested, even if it has its defenders.[16]

Technology transfer offices have sprouted up at universities and research institutions, but most discoveries are licensed to a big corporation in one or another way. Over the past decade companies have been focusing more on "D" than on "R", reflecting a sense of greater pressure to get products more rapidly to the market.[17] Research seems to wane in relative importance, and much of it is seen to move from corporate labs to universities.

As noted above, increases of external funding and problem-oriented research in many countries has gone on at the cost of faculty-funded efforts and relative autonomy in some decision-making. Consequently university personnel also complain of being weighed down more than before by an increasing number of different tasks alongside their traditional core mandates - "task congestion". [118] Demand for greater efficiency brings with it new terms, like scientific "deliverables". These are aforehand thought-out packages of results that are supposed to emerge from publicly funded R&D. The concept of "value added" (especially prominent in EU rhetoric) also suggests a turn in the way potential output of projects is construed in terms of instrumental utility. In the face of all this the old fashioned ethos of research "for the good of your soul" is held *both* to be in decline *and* making a comeback.

Strategic research and efforts at foresight

Recent studies indicate how many of the large multinational corporations now use a strategy of concentration on worldwide centers of excellence.[19] In biotechnology, for example, there are two types of firms, those that try to produce the next drug, and those that are trying to create new biotechnological knowledge and selling that knowledge in anticipation of the next wave of products 20-30 years hence. The former are concerned with applied research, while the latter focus on strategic research, e.g., relating to chemical molecules and the malfunction of specific genes, and not the more controversial areas of gene therapy or modification. This gives rise to a corresponding division of labour, where most firms maintain their role as product developers and universities, despite many changes, still continue as the home of fundamental research and certifiers of excellence.

Research foresight exercises are now used to identify new and emerging technologies with an eye on future competitiveness in the global marketplace, both industrial and academic.[20] The aim is to stimulate the science base for economic growth with the help of some kind of anticipatory intelligence, involving as expert advisers researchers and planners from academe, government agencies, and industrial enterprises as well as an ever increasing number of consulting firms. Foresight is a social process of bringing the key actors involved in innovation together around concensual goals. Hitherto focus has mostly been on high tech innovation and a technocratic slant, but voices have been raised to bring in social dimensions and environmental objectives, as well as citizens' and so-called "end-user" groups. In response to this in the 1990s there were several attempts to broaden stakeholder participation by including more representatives of NGOs such as consumer groups and environmental organizations and civic society users of knowledge. Consensus conferences and other forms of public consultation are also used.[21]

Three domains, microelectronics or IT, biotechnology and new materials research and development were the core generic high tech areas of the 1980s. They are now key ingredients in what is sometimes called a new scientific-technological revolution that not only transforms our lives in society but also challenges us to rethink what it means to be human. Existential, ethical and legal issues emerge and call for research collaboration also across faculty boundaries, between humanities and social sciences on the one hand, and fields in the natural sciences, biomedicine and engineering sciences on the other.

Linking science with commercial interest, and conflicting norms

The conscious and planned fostering of cooperation between academia and industry is diverse. After technology transfer offices and science parks as parts of regional development strategies came national investments in strategic research centers involving university-government-industrial partnerships. The rationale has been to create new internationally competitive research environments with interdisciplinary foci and strategic import for industry. An earlier form in the U.S. was that of the National Science Foundation funded engineering research centers.

On the less applied side there is the notion of centers of excellence, also meant to enhance scientific performance as seen in the mirror of globalization and competitiveness. During the past decade too there has been an increase in the numbers of institutes of advanced studies. The latter may be understood as new forms for immunizing fundamental scholarship from the pressures plying the mainstream academic scene, a compensation for loss of concentration on the basics in university settings. Thereby such institutes reflect the continuing robustness of the traditional academic values and practices.

Linking science with commercial interests in the current landscape gives rise to conflicts over norms and traditions – academic vs. commercial. A key question is how this problem is to be tackled. Here the perspective assumed in some of the new models of research policy becomes crucial. Questions arise: are academic norms being replaced, are they being fused with, or perhaps over-layered by commercial norms, and is peaceful coexistence of different norms-systems possible; if so, in what way?

Summing up

Several features stand out as cross-cutting dimensions: (1) new and emerging or generic technologies are more immediately based than before on fundamental research; (2) this facilitates establishment of huge databases in electronic form and rapid exchange and reconfiguration of information gets translated into knowledge after appropriation at local sites and with the application of appropriate skills and competence; (3) globalization intensifies competition, especially around scientific fields that have potential as an economic market resource; (4) collaboration and competition go hand in glove, with the formation of coalitions for mutual benefit and exclusion of competitors plus more poorly endowed actors; (5) networking and partnering become the new buzzwords, with new sharpening of mechanisms of inclusion and exclusion; (6) related to the foregoing there is a steady increase of researchers collaborating across both epistemic and geographic boundaries – there are new forms of interdisciplinarity and international collaboration unevenly dispersed across the center-periphery relations that to some extent replicate the world's economic and social inequities; (7) foresight and priority-setting exercises reinforce this in the bringing together of diverse actors to hone harmony in networks and research agendas; (8) at the policy level this is reflected in the rejection of the linear model which is now replaced by thinking in terms of networking and partnering, with policies of orchestration. These involve multiple actors with university-industry-government interplay conceptualized as mutual interaction within evolving triads.

In the next section I turn to some of the new concepts, models and metaphors relating to "knowledge production" that have arisen around the processes highlighted above.

Theories of reconfiguration

Mandated science

This is a notion that emerged out of regulatory science several decades ago. It was introduced by Liora Salter and William Leiss, who used it to denote scientific expertise in agencies responsible for setting limits to toxic emissions in the workplace or overseeing industrial practices that may negatively impact citizens' health and welfare.[22] For the most part it refers to science in the public sphere where particular agencies are in place to set environmental and health-related standards, e.g., Environmental Protection Agencies. Such organizations do in-house research or farm R&D out to academic departments and consultancies. Thus the term is contextually contingent predicated on the prominence of state bureaucracies and other authorities. With the rise of neo-liberal politics, deregulation and privatization trends, it fell out of favour, and is now overshadowed by a number of newer terms that pretend to be less normative and no longer put an equally clear accent on the common good.

Postacademic science

The notion of postacademic comes out of a “limits to growth”-thesis applied to national research systems. The idea is that academic budgetary limitations are offset by external funding that impacts the conditions of research, leading to shifting priorities and contending norms, from CUDOS to PLACE (see below). John Ziman, who launched this thesis first, coined the expression “steady state” to refer to a resource ceiling. When it is reached innovation gets constrained by a fixed budgetary frame.[23] New investments imply constrictions in existing areas, or increases of efficiency in resource utilization (hence a sudden proliferation of evaluations) and other forms of rationalization. Therewith new modes of cooperation are forced to emerge, not least across national borders. This, Ziman held, induces increased collectivization and internationalization of knowledge production.[24] Priority-setting becomes more painful.[25]

As ability to capture external resources became more important for the productive research milieu, one got stronger calls to meet new challenges with the help of risk capital, entrepreneurial competition, and enhancing academic budgets by taking out patents. In the process, Ziman found, the traditional norms associated with academic work were over-layered with a new set of norms, challenging basic academic values and freedoms.

Some academics fear traditional norms and procedures may get crowded out. Elzinga has suggested “epistemic drift” may occur, when criteria of internal quality control of scientific research get subordinated under external criteria of relevance and social accountability.[26] Ziman spells out the new norms in an acronym: PLACE (Proprietary, Local, Authoritarian, Commissioned Expert work). [27] From having been a vocation or “calling” science becomes a “job”. The argument is that the transition or shift from CUDOS to PLACE may also to some degree influence researchers’ understanding of their role and identity, either changing these, or else sharpening their awareness of traditional values and norms, leading to a clearer articulation of the same.[28]

Mode 2

Gibbons et al. focus on application-contexts, reconfigurations for commercial value added, and socially distributive systems of knowledge and competence. Mode 1 research is typically centered on disciplines, with academic hierarchies, homogeneity and a distance between discovery and application of new ideas. By contrast Mode 2 research is problem-oriented, transcends disciplinary boundaries, occurs in and internalizes the context of application; it is much more heterogeneous. Both modes may appear at one and the same site, and there is taken to be a transition between them, rather than input/output relations between two distinct organizations. Interaction and patterns of communication, rather than sequential steps, are the key variables. Thus innovation is no longer pictured as an input/output function where intention is supposed to steer outcome; rather it becomes a network characteristic. It is distributive (and distributed), open-ended, involving recombination and re-configuration.

This, the de-linking of sites of knowledge production from sites for creation of new marketable products suggests a stochastic relationship between research efforts and utilization of results. Consequently, innovation becomes a network property. Density of communication is a key variable. "An increase in the density of communication is an indication that the rate of diffusion is increasing....". [29] Innovation and diffusion of new things appear as a property of increased rate of communication, and no longer (as in the linear model) something travelling through space. The gradient line is moved from space to time. Speed is depicted as a decisive factor that is used to explain the uneven development of science across the globe and between speciality areas. This in turn hinges on unequal economic and infrastructural resources, thereby reinforcing hegemonic patterns. "Ability to engage in research and to utilize it remains highly unevenly distributed throughout the world. An actual increase of inequalities occurs also through the differentiating effects that globalization has on the actual ability to participate in the consumption of scientific knowledge, advanced technological products and systems, which leaves many regions and countries locked out completely."[30]

The model plays up networks and permutations within them, as well as communicative capacities and speed as more important than traditional attributes like ownership, power or control. And, it singles out, isolates and underlines two functional aspects, standardization and diversification. "In general we hold that inequalities of distribution have become more marked in the course of the process of global diffusion of knowledge production. The ability to transmit information cheaply and almost instantaneously throughout the world does not seem to lead to a more equitable distribution of scientific competence, but rather to its concentration. The growth of inequalities can be traced to the combination of two built-in tendencies; one towards standardization, the other towards diversification."[31] Despite descriptive pretences that occasionally verge on criticism, the Mode 2 scheme nevertheless is mostly read as normative, i.e., as condoning of commercialization and macro-economic globalization trends.

Triple helix

The triple helix model emphasizes changing communication.[32] Real existing coalitions created in various countries under the auspices of science and technology policy programs, viz., university-government-industrial complexes operating at pre-competitive levels, are schematized into a simple model of trilateral interaction involving continuous permutation of roles in three symbiotically ascending spirals. Innovativeness is explained as a product of coalition building and networking patterns, prompted by quests for competitive advantage, leading to clustering and a nesting of inclusion mechanisms. The circulation of capital resources is again held to be less important than symbiotic patterns of communication. Consequently convergence and agreement is highlighted while potential conflict and exclusion mechanisms are toned down, giving rise to a picture of smooth and peaceful collaboration across institutional borders. Democratic corporatism becomes a policy norm for overcoming difference by creating new hybrid forms of organization. "Translation" between the cultural codes inherent in the three different sub-systems (university, government and industry institutions) is what matters most, and this occurs in a continual process of interaction, communication and negotiation. This focus reflects a totalization of the pre-competitive domain, where carrying agents actually do interact consensually in foresight exercises and conceptualization of possible recombinations and reconfigurations to home in on one or two such at a given point in time.

However path dependency shaped by previous institutional arrangements also makes a difference that has to be factored into the model. Mutual learning in the process of permutation and change centered on semi-dependent self-organizing ensembles is called co-evolution. When an optimal reconfiguration is reached, in model language one speaks of stability, and if it is enduring, it becomes a question of a technological regime or knowledge-producing regime.

Trilateral networks and hybrid organizational arrangements are constantly supposed to be created, reproduced, modified and destroyed. Co-evolution revolves around a coming together of cultures that compete for a share of economic development. Ability to recombine and reconfigure requires flexibilities and reflexivity in the roles of the institutional carriers or stakeholders. Industry is depicted as being able to draw upon interlinkages with academe, while governments are taken to have co-ordinative and policy functions, as well as contributing to costs.

Academic capitalism

Relevant background conditions are more clearly articulated by Slaughter and Leslie (1997), who fix on globalization pressures, withdrawing of funding of a knowledge commons, and hence the emergence of sharp competition within academe – capitalist-like behavior. This is held to influence norms and identity in academe, with splits between junior project-based and senior faculty-funded researchers.[33] Their model clarifies aspects that the Triple Helix misses in describing the linkages at hand. Key is macro-economic globalization, IT and neoliberal politics to induce deregulation. The synergy of these three processes ultimately has strong repercussions on academic life. The state is induced to withdraw public responsibility from activities which otherwise fall under a "commons". This leads to privatization, e.g., of health care and higher educational facilities, expansion of entrepreneurialism, intra-academic competition, and thence at the meso- and micro-levels, a capitalist-like behaviour on the part of researchers and teachers. Researchers and teachers are not really capitalists in the sense of being able to accumulate capital. Rather they are depicted as taking over market-oriented norms that make them compete and act in entrepreneurial fashion within academe in order to accumulate advantages vis a vis rivals that belong to other departments or disciplinary formations.

If interdisciplinarity can provide a competitive advantage then researchers will go for it, possibly after weighing in the cost of lost opportunities associated with alternative strategies. Thus academic capitalism tends to incorporate a norms-system where opportunistic cost-benefit analysis reigns over the proverbial altruism of old. Still, the model does not suggest that the newer norms will crowd out the older ones; rather both sets of norms and values continue side by side, and within each individual researcher. It is the context that contributes to evoking the one or the other.

Post-normal science

Post-normal science as a concept focuses on science that operates in areas of high uncertainty where there is a strong demand for expert advice, e.g., research on global climate change. BSE or mad cow disease and genetically modified consumer goods are other examples. Political and economic stakes are high, epistemic certainty is low, and the local matters. Thence consensus conferences and extended peer review procedures also involving non-experts become the order of the day. Thus internal peer review criteria to assess the quality of research get over-layered with criteria for evaluating the social relevance of a piece of knowledge. A natural scientist working on, say paleoclimatology, is no longer regarded as only part of an academic research system. S/he is at the same time part of a politically mandated system to asses and come to grips with a major threat to society, viz., the enhanced greenhouse effect. Strong political and economic forces come into play to pull the researcher into different directions, threatening the integrity of the research process. Soft natural science, it is postulated, feeds into and - under pressure - is influenced by a hard political arena, or as Ravetz puts it, “the facts are uncertain, values in dispute, stakes high, and decisions urgent”.[34] Once science is carried beyond the “artificially pure and stable conditions of laboratory experiment”, and into society, established facts tend to lose some of their reliability. This is seen in discussions regarding measures and timetables for reducing the emission of greenhouse gasses at the source - cf. events and controversy regarding the Kyoto Protocol. The harder political climate influences both research agendas and modes of reporting. Mass media also enter into the picture. NGOs both on the side of business and on the side of social movements participate in assessing scientific results; the Intergovernmental Panel on Climate Change (IPCC) is an interesting institutional manifestation of this. Similarly consensus panels and ethical committees operate in other fields to constrain and regulate scientific knowledge production and technological development (e.g. GMOs, stem cell research, or the use of animals in biomedicine or pharmaceutical research). This can be seen as both an indication of failing public trust in science, and a means to re-establish trust. It introduces a managerial view and is a far cry from Thomas Kuhn’s “normal” puzzle-solving science, which is often taken as paradigmatic for all research. “Whereas before one could imagine science advancing boldly, steadily rolling back the frontier between knowledge and ignorance, now we must cope with our ignorance of the ramified effects of science-based processes. The ‘hard facts’ for which science is the paradigm example are, in these new problems, painfully conspicuous by their absence”.[35] In the ideal of normal science truth claims are universal. In post-normal science local conditions become important. “When problems lack neat solutions, when environmental and ethical aspects of the issues are prominent, when the phenomena themselves are ambiguous, and when all research techniques are open to methodological criticism, then the debates on quality are not enhanced by the exclusion of all but the specialist researchers and official experts....Knowledge of local conditions may determine which data are strong and relevant, and can also help to define policy problems. Such local, personal knowledge does not come naturally to the subject-specialism experts whose training and employment predisposes them to adopt abstract, generalized conceptions of genuineness of problems and relevance of information”. [36]

This means science-society boundaries are continually subject to negotiation and redefinition, and that interdisciplinary approaches replace more traditional puzzle-solving, which has become inadequate.

The concept of the agora

The authors of *Re-thinking Science* pick up on some of these aspects to go one step further. They write: “Of course, Mode-2 knowledge production is not free from all planning foresight, nor from bureaucratic controls. But an important shift in the regime of control has taken place. Instead of being exercised directly from ‘outside’, control is now exercised indirectly and from ‘inside’. It is becoming internalized through mechanisms that also characterize the so-called Audit Society. These mechanisms include ever more elaborate systems of peer review, more formal quality control systems and other forms of audit, assessment and evaluation designed to police the consequences of the greater variation of research potential and practice which has been generated by increasing competition.

But these practices also create spaces which leave much room for different kinds of (half-blind) strategies in which selection through what counts as 'success' - defined by different kinds of actors and under varying circumstances - can be achieved. These are the many tiny, and not so tiny cracks in the fabric of scientific knowledge production through which contextualization enters." [37]The *agora* is proposed as a new public space where multiple actors co-mingle with researchers to shape agendas and results.[38]

Contextualization depends on continual dialogue between scientists and diverse groups of other actors in society, and in the process capacities are built for translating knowledge into action. Another way of putting it is that the knowledge becomes "socially robust", a feature that appears to reflect a high degree of consensus within science and between scientists and the other actors in society at large. To regain public trust, it is argued, science has to move into and achieve stability in a "wider *agora*" where initially it may be contested on both epistemic and political grounds, but can become socially robust via extended peer review or hybrid consensus processes. This must occur at local sites, and consensus may well fall apart at other times and in other places.

As a metaphor the notion trades on its association with the original *agora* in the city-states of ancient Greece, a public space or trading zone where different opinions and truth claims intersect to meet new challenges. The difference is that the modern *agora* is defined as being "populated by a highly articulate, well-educated population, the product of an enlightened educational system."[39] From the traditional democratic point of view science is seen as an external force and resource to be mobilized to serve Enlightenment and production; from the new point of view this is no longer so, science "is now an internal force, pervasively (if still reluctantly) present in the *agora*."[40]In this state of affairs knowledge claims are supposed to be recognized as the outcome of complex negotiations and constantly subject to re-negotiation, whence boundaries between disciplinary specialities and between science and society tend to shift, at least in the perception of the beholder, and that is what counts.

Nomadic knowledge production?

Nomadic knowledge production is a scheme that emerges from an idealization of the Internet and cyberspace. Its point of departure is the equation of knowledge with information, therewith ignoring the personal skills, competence or "social work" required to access information and translate it into knowledge. This is a blindspot that emerges from fascination with the marvels of the Internet, leading to dreams of nomadic knowledge production.

The idea is simply that of a knowledge production increasingly freed from constraints of locality, of space. One can work from anywhere, so the view goes, to participate in the new knowledge society. One may sit at an airport, or on the beach on Bali, or perhaps somewhere else on the move. It is only a matter of hooking up to the Internet and move assets around instantaneously, both material and immaterial ones, capital and intellectual property.

Assuming that knowledge flows freely on the Net, the process of transferring information to knowledge is seen as mere conversion and recombination. The nomadic knowledge agent intervenes and contributes to reconfigurations that give new knowledge, socalled added-value, eventually capable of being sold on a market. Since the process is supposed to be instantaneous, it becomes meaningless to speak of diffusion. A better image would be of something moving through worm-holes in hyperspace. Action is at a distance. Agency is made elusive.

Critical points

The new models do focus on many important changes in the science and industry landscape of the past twenty-five years. Critics have however found several major weaknesses, e.g., the models:

- select limited aspects of perhaps 1/20th of the total research landscape;
- stylize real conditions and events to produce an image of an abstract (interstitial) agency space;
- exaggerate commonality and consensus between different actors and stakeholders, while playing down differentiation and conflict of interest arising from incommensurable systemic specificity;
- introduce a reflexive deficit in that the interactive model that replaces the linear one fails to take proper account of the context and force of globalization and its impact on the conditions of research;
- lose the epistemic dimension by lumping together science and technology into a reductionist notion of "technoscience"; thus
- replacing science policy by innovation policy;

Discussion of these points follows.

One-eyed stylization to an abstract interstitial "space"

One critic writes that the Mode 2 scheme portrays science as if "research takes place in a totally deinstitutionalized, fluid and amorphous environment."[41] It has very little to say about the university as an institution; neither does the Triple helix. The strong focus on information and communicative behavior erases the significance of real-time skills and competence. The construct of the "agora" in its ambiguity invites a similar reading.

One argument against overly stylized conceptualizations of the "new" hinges on the difference between knowledge and information. Information is codified and can easily be moved around in cyberspace, but to translate it into knowledge requires human appropriation, which in turn presupposes access to certain kinds of resources, as well as special skills. It is a matter of moving from disembodied to an embodiment of capacities. One way of putting it is that knowledge is "sticky", its realization requires active social work, tacit skills and collective organized social efforts embedded in viable infrastructures. As critics of the notion of nomadic knowledge production have pointed out, virtual encounters in cyberspace gain meaning for its incumbents only because of physical and social encounters in other contexts.[42]

In the reader's mind Mode-2 and Triple helix notions conflate cyberspace and knowledge, as also knowledge production and cyber-capitalism (i.e., a mode of rapidly moving around assets from one site to another in the world). The confusion arises from the failure to elucidate the differences between technical aspects regarding enhanced capacities for rapid re-configuration, and the question of property rights in contexts of application. Actually, Mode 2 change is not so much focused on organization as such but rather on the differentiation of organization. Weingart refers to the model's failure to analytically distinguish between functional differentiation on an institutional level and the changes of organizational boundaries.[43] That the models are presentist in their approach has been pointed out by several critics and is also admitted by one of the primary authors herself.[44] If one focuses universities, governmental agencies and industrial firms in the prism of institutional analysis, then inertia, path dependency and elements of mismatch become much more important. This, in turn, has significant consequences for science and technology policy (see below).

Value-bias
Several critics have picked up on what they consider to be a value-bias inherent in some of the models. Terry Shinn refers to it as a partisan stance influenced by the advocates' own location in the science policy landscape: "Careful examination of the new production of knowledge production hypothesis and triple helix model suggests that the discontinuist message more often reflects a partisan political agenda and ideology than it does serious-minded history and sociology. Several of the most vituperative radical discontinuity advocates are themselves government and industry actors or consultants. Others, closer to academia, have hitched their career to radical discontinuity studies - financing their research work via industry and government coffers."[45] Weingart also suggests that some of the new models are not so much descriptions of actual changes but, rather, largely prompted by their context of emergence.[46] Pestre refers to them as having a quasi-political function. The descriptions offered, he says, entail values that in the absence of clearly articulated critique to the contrary, fall into the trap of condoning neo-liberal deregulation and the economics of globalization.[47]

Whatever the reason, one ends up with a new reductionism in the framing of the new models of knowledge production.

Exaggeration of commonality amongst actors
The models' exaggeration of communality and consensus has received relatively less attention in the debate. Etzkowitz, who calls his own inclination "democratic corporatist", writes: "As scientists engage in research, and the gathering of resources with which to conduct research, they create firm-like entities or 'quasi-firms'. Quasi-firms operate according to the model of classical capitalism as small entities competing for resources. Firm formation, then, is merely a further step in the process by which scientists create research groups at universities, institutes and corporations, rather than a discontinuity in practice".[48] In the Triple Helix metaphor, systemic specificities between research and industrial policies tend to get wiped out, just as do differences of value systems and norms between academe and the spheres of business enterprise. "As the university acquires an industrial penumbra, industry takes on some of the values of the university, sharing as well as protecting knowledge".[49] Stakeholder interests appear to fuse, as the research community "serves the surrounding society, and especially industry in the development of marketable knowledge; that is the message in the theories of Mode 2 and Triple helix."[50]

The democratic corporativist assumptions are less obvious in some of the other notions, like Mode 2, postnormal science or the *agora*. Ziman's image of post-academic science *is the exception*. He argues that closer relations to industry and external relevance pressures do not necessarily lead to a weakening of traditional academic norms. On the contrary, these and the ideal of free research and neutrality tend to become stronger as they are complemented with new norms, which underscore the social role of science. Such a contrarian conclusion follows from a greater sensitivity to the dialectical nature of interplay of unity and contradiction of opposites, rendering institutional differences in terms of norms, epistemic criteria as well as policy cultures and path dependencies much more significant

In an anti-corporatist perspective the challenge of new regimes of knowledge production with strong relevance pressures is found to lead to clearer articulation of difference, and modification of boundaries rather than their dissolution. The question of quality control and evaluation procedures becomes a centerpiece for analysis. That this is tricky key question deserving much more attention is admitted by Helga Nowotny.[51] In my own previous work I have been concerned with these dimensions,[52] finding, like Frans Birrer, that one cannot equate re-combination with hybridization, nor hybridization with fusion when it comes to norms and criteria.[53] Fusion of knowledge modes only occurs when a new form emerges in its own right, largely independent of the earlier modes out of which it may emerge. In hybridization it is a question of "interlopers" that move between two existing modes which continue to play an important role, while combination of knowledge modes is found to occur on the basis of an articulation and mutual respect regarding the relative autonomy of systemic differences.

From this perspective boundaries become more and not less important; quality control is much easier to uphold if it is shielded from circuits where other criteria rule.[54] Therefore it is not surprising to find that review procedures for basic research and for mission oriented research actually involve quite different goals, remits, metrics and procedures, as well as time-scales. This has been emphasized by hybrid actors responsible for funding programs, for example Ronald N. Kostoff at the Office of Naval Research in the US, who on the basis of experience insists that, "it is extremely important that the tools used to enforce research accountability do not destroy basic research". And further, "the intrinsic long time scale, characteristic of basic research conflicts with the short-term emphasis of much of the corporate world, where annual reports and requirements for quarterly financial performance shorten the production period for research results. This near term focus on financial performance has essentially eliminated long-range high-risk fundamental research financed from corporate funds in most industries".[55]

In view of the above it is clear that in the long term large corporations find their interests better served when research universities adhere to a principle of division of labour where academia, instead of trying to mimic industrial firms, is to expand and uphold the integrity of fundamental research and concomitant quality control procedures. This is also evident in the new contractual arrangements being forged by brokerage firms at the university-industry interface. Predicated on a recognition of the difference of the two missions, they seek to boost commercialization while protecting the integrity of basic research units, on the principle that maximizing intellectual infrastructures of the university setting is a precondition for enabling commercial exploitation, for example in molecular biotechnology.[56] Partnership with independent high quality academic research institutions also enhances the image of private industry and is increasingly used as a sales argument in competition in the global marketplace.

Policy consequences

In terms of policy the assumptions of homogenization subordinate science to innovation policy. This introduces loss of the epistemic dimension (*epistemic deficit*), rhetorically reinforced by a new vocabulary, e.g., the concept of *technoscience* - introduced by both evolutionary economics and actor network theory. General emphasis of hybridity does the same thing when not balanced by cognizance of institutional differentiation and functional specificity of the systems in which the collaborating actors are ultimately anchored. Conflation of science with technology provides justification for subsuming science policy under industrial policy or simply calling everything innovation policy.[57] This invites intervention on the basis of values and goals external to the logic of scientific discovery, so that more traditional core interests of academic communities and their internal needs get neglected or run over. As research becomes more policy-driven, policy makers in the public domain try to second-guess the needs of commercial users and end up introducing organizational novelties that the latter may not be very enthused about. Instruments of technology policy do not provide an alternative to basic research; rather they tend to eclipse it. Mode-2 authors are unclear about this, although they sometimes appear to condone an entirely new order, since they write how national institutions need to be de-centered to be made more permeable.[58]

There is some evidence around now that the new institutional arrangements grafted onto academe do not have the deep-going impact that has been claimed for them - e.g. technology transfer offices, university-industrial liaison offices.[59] Krücken has shown this for technology transfer offices at German universities.[60] One of the virtues of the now defunct linear model was that it was used to set boundaries and facilitated an articulation of academic stakeholder interests more clearly as a precondition for interaction and collaborations with other actors. On this basis hybridity later came to mean accommodation of interests and activities for mutual benefit, but on the basis of a clear recognition of differences in terms of goals, values and norms. In some of the newer models, on the contrary, hybridity is understood as a kind of fusion of interests, norms and values. Younger researchers, particularly those, whose fortunes are dependent on short time funding, have been more alert to what they experience as dire consequences to potential academic career trajectories in university-based service oriented units where the Mode 2-philosophy is the main practice.[61]

Failure to clarify the global context

Gibbons et al. mentions supranational institutions like NAFTA and GATT (followed by the WTO) as laying down the rules for nesting relationships. At times the authors appear ambivalent about the "model's" embedding in globalization. They condone it on the one hand, but on the other hand they express moral and political concerns, wanting to see stronger controls on behalf of civic societies. One comes to think of a brokerage relation, with collaboration to achieve greater competitiveness at another level. Neo-liberal technocratic and social democratic corporatist interpretations of the metaphor form two poles in a tension still requiring historically informed alternative visions that take up the missing dimensions.

Redistribution of sovereignty, power and freedom to act are the dimensions Gibbons et al. allude to when they speak of a paradox associated with "reconfigurations" in knowledge-production landscapes, with standardization and diversity pulling in opposite directions. This insight, however, remains abstract. We have to go to a different literature to fill in the implications concerning power, control and hegemony. In the words of one of today's critics of globalization the processes of communication and translation modeled in mainstream macro-economic discourses also entail "redistribution of privileges and deprivations, of wealth and poverty, of resources and impotence, of power and powerlessness, of freedom and constraint."[62] A basic premise is to facilitate the logic competition as against the logic of community, while at the cultural level making it appear otherwise, i.e., representing current changes as a matter of increasing freedom, mobility, democracy and individual choice.[63] Research policy doctrines and models that fail to be clear about this point will end up serving a culture of mystification in the ongoing struggle around two logics, that of the global systems economy versus the logic of the living social context in which restructuring is taking place. The former tries to silence the latter. Free trade, for example, is asymmetrical internationalization.[64] National and regional economies are being refitted as modular components of an increasingly global corporate economy controlled by transnational management information systems.[65] Viewing intellectual property from a macro-level, world-systems perspective, it is possible to see patents as a means of reinforcing existing distributions of power.[66]

The relationships induced by globalization are by their very nature ones of inequality. The notion of freedom to act becomes synonymous with the notion of freedom to move, and speed is the new measure. The extent to which a region, a country or a local site is drawn into globalization has become the new measure of its stage of "development". What is at issue then is a matter of two contending logics: competition and community. This is a point on which many of the new models are unclear, since they seem to assume the possibility of a fusion of interests as the basis for consensus or social robustness in the arenas where science and politics meet. This comes through most clearly in the Triple Helix model or metaphor.

More broadly the rhetoric of much of the "new production"-talk may thus be interpreted as part of the self-effacing culture of globalization that hides inequities and aggressive deeds by nice-sounding words like freedom, deregulation or reconfiguration. Culturally the new models map elements of (macro-economic) globalization and network thinking into research policy. Failing to clarify the contradictory principles of interconnectivity between university-industry-government or with environmental or consumer-oriented NGO-actors, the models covertly tend to resonate with the logic of the profit nexus more than that of solidarity.[67] This is reinforced by generalization from limited segments of the current landscape, e.g., university-industry cooperative schemes or particular branches like the pharmaceutical industry and areas of biomedicine, evident in the sequel to the New Production of Knowledge-book, while advocates of the Triple helix are more ambiguous about it.[68] During the 1980s we have seen the emergence of neo-mercantilist doctrines in various domains. Neo-liberal ideologues with their free market and deregulation talk suggest we are witnessing a withdrawal of the state, whereas in practice with the WTO and EU-policies we are actually experiencing stronger socio-economic intertwining that go beyond the state/market divide. In the EU the state is actually an active player in S&T policies. What is needed therefore are efforts to demystify the current neo-liberal and deregulation talk rather than turning research policy doctrines into its tacit echo.

Missing dimensions

Two questions fail to be addressed. One is the significance of the new computational methods in the sciences. The other concerns the future status and role of academic disciplines.

The significance of computational methods

Recent advances in computational methods and semi-automated techniques for data processing, pattern recognition and the like, some analysts suggest, represent a return to an earlier mode of knowledge production, the one associated with taxonomy and natural history. In this perspective we get an account in which one can trace a movement from a crafts mode of knowledge production in the 17th century to taxonomy and natural history. In the following centuries came a focus on processes, and hence analysis, and then to the systematic, controlled recombination of elementary properties into synthesis, the production of novelty, in the laboratory and for industry.[69] In our own time recombinance and synthesis has taken a turn to the miniature (miniaturization), adding to the power of the synthetic products, although I want to underline that the present day focus on the systemic does not only take place in commercial realms. It overlies and frames earlier heuristic approaches in many a field.

In the 19th century the significance of the new laboratory science was much debated. For some laboratories appeared as an artificial constraint of Nature. At least three lines of thought emerged: (i) pushing Nature into the laboratory; (ii) moving laboratory experimentation into the field (field stations), and (iii) regarding Nature as such as a grand laboratory. In the second case the variables were also restricted and controlled, in association with the work of classification and taxonomy. Whereas natural history might align with inductivist methodologies, laboratory experimentation tended to go hand in hand with hypothetico-deductive and predictive ideals. Even in the field numeric grids might be placed over natural plots to translate local properties into more general ones.

In analogy with the discussions of the 19th century there are three parallel figures of thought: (i) putting Nature into the computer (simulation, virtual reality), (ii) deploying the computer in the field (automated data collection and assembly, computer-aided observation), and (iii) taking Nature as a computer (both in terms of models informed by communications theories and semiotics, and in terms of constructing bio-computers). The difference by comparison to the natural history of old lies in the techniques, whereby many operations are delegated to machines. These review vast databases and do so very quickly, but it is still humans that ultimately do the work of interpretation. What is new is the focus on the systemic, as we can see it in systems biology, earth systems science, general circulation models and subsystems in climatology, for example. These, I find, are more important than the organizational and intellectual property relations that get dramatized in the new theories of knowledge production, which for their part, because they are so focused on limited segments of science, obscure the epistemic dimension.

Bioinformatics, proteonics and particular areas of nanotechnology are hybrid fields, strongly marked by new computational methods, but also by their intimate ties with the world of application. In this sense they remind of research in agriculture, engineering sciences, and clinical medicine "First introduced in pharmaceutical industries for the design of new drugs, the combinatorial method consists in synthesizing a large array of compounds at once and then screening them to discover interesting structures. It has been employed in materials science in the quest for high-temperature super-conducting materials".[70] Combinatorial means co-mingling substances to form something new; to whet the public imagination journalists also refer to "the new alchemy". One seeks the "fittest" structure, which is then licensed and commercialized.

Largely then, it is a question of semi-automation with human interaction, where pattern recognition is speeded up and done on a scale undreamed of before.

Epistemically, classificatory work framed within today's so-called technosciences is more often linked to attempts to further analysis of systems at scales from organs, tissues, cells, to the molecular, or in materials science to the atomic levels (nanotubes), and in geology magnetospheric, atmospheric, oceanic, mantel, fluid-to-solid core systems of the Earth. In astronomy we now have virtual observatories, also facilitated by the newer breakthroughs in computational techniques and infrastructures. All these represent further steps in line with methodologies and modes of analysis that have been around for some time.

The educational and quality enhancing role of academic disciplines

There is proliferation of subspecialties in science, and greater permeability between knowledge domains. In my own university 30 years ago, the physics department had one seminar, whereas today there are 20 parallel seminars in the same but much expanded and differentiated department. Still, physics, chemistry, geology, biology, pathology, glaciology, genetics, etc. remain primary areas in which one is certified as an undergraduate major. The same cores are also relevant in designating PhDs. The major learned societies joined by the International Science Council (ICSU), "classes" in academies of sciences and arts, and the workings of the Nobel prize institutions continue to do their share in undergirding disciplinary divisions and identities. Job announcements in Nature and Science, even when recruiting positions in bioinformatics and proteonics, most often call for a strong core foundation in classical genetics, pharmacology, biology, computer science or applied mathematics. New materials science does not make up a disciplinary community either. It is made up of physicists, chemists, metallurgists, mechanical engineers or chemical engineers, defined therefore "by their respective backgrounds rather than by their current field of research."[71]

Solid expertise in a primary core discipline also remains in other fields like radio astronomy, geomorphology, oceanography etc. Here too, computational methods and visualization technologies have a strong impact, but without the lucrative monetary profits and hence without the mega-amounts of private funding to speed things up and render them visible and talked about as in the case of the hybrid domains of IT, biotechnology or nanotechnology. Priorities are certainly telling. Natural history museums all around the world house altogether more than two billion fossils and specimens, which are, still largely catalogued on handwritten or typed archival cards. These are now in the process of being put into electronic databases, but at the present rate this will take about ten years. If an amount of funding and energy comparable to that going into computational biotech was plowed into this area the project could probably be completed in half a year.

In the 21st century institutional orders of certification and systematic specificity in the ways of the natural world, in the laboratory and outside in the field, will probably continue to influence the recognition of certain broad areas as disciplinary cores. Relevance and accountability pressures, as well as further articulation of quality control mechanisms will also tend to push in the same direction.

Concluding remarks

The projection of new research policy models fixes only on a small cluster of areas in a broad and variegated tapestry of modern science, which includes all kinds of sites and institutions. They largely take events in areas like biotechnology and microelectronics and now also increasingly research into advanced industrial materials as their main reference, areas where the promise of commercial profits is strongest. We hear nothing about changes in astronomy, natural history museums, language laboratories or departments of archeology and musicology. Thus the new models are fostering a new particularism while claiming generality. Furthermore, they conflate technical characteristics of semi-automation in knowledge production at the science-society interface. Consequently, the new images of scientific knowledge production have a social epistemology that is rather limited in scope.[72] They are ideologically coloured totalizations of another segment of the knowledge production landscape. In the new metaphors, contexts of application tend to merge with domains of privatization and commoditization, even if in the face of criticism some latter-day advocates of the newer images have retreated to a position of wanting to give recognition to non-commercial users, NGOs and representatives of civil society.

Earlier policy models, like the linear model of innovation, Don K. Price's image of "Truth speaks to Power", or Robert Merton's CUDOS norms-model all had clear boundaries between science and society and were predicated on powerful metaphors that assumed clearcut boundaries between science and society. They can be seen as the product of a post-World war II social epistemology, and once commonly accepted they came to function as social facts. In present-day discussions regarding the "new production of knowledge" or a "new social contract for science" new images and metaphors are replacing old ones, this time predicated on a social epistemology informed by globalization and the alleged fusion of different stakeholder interests.

The new models and metaphors are therefore no less reductionist than their predecessors, but given the new context they serve to reinforce and legitimate new organizational arrangements with an accent on hybridity and porosity. In the wake of a continuous stream of workshops and conferences with policy-makers and research administrators they have become a social fact (self-fulfilling prophecies) in some policy circles. The Triple Helix conferences, for example, are actively used to propagate the message in connection with technology diffusion to third world regions. Also transmitted are organizational forms and guidelines for a new mode of knowledge production and concomitant methodologies for assessing related landscapes. In this respect, just as in the early 1960s when the first science policy doctrine and its linear model were enunciated, the OECD offices in Paris now joined by the EC in Brussels, also continue to play an important role.

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* The author wants to thank several participants of the Nobel symposium in Stockholm Nov. 2002, particularly Donald MacKenzie, as well as later, Georg Krücken (Bielefeld) for valuable comments on an earlier version of this paper. A different version will appear in Karl Grandin ed. The Nexus between Science, Industry and Policy….Autumn 2004 – check with Grandin via <http://www.center.kva.se/English/Center.htm>

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