Universities and Public Research Organisations in the ERA

Fulfilling universities' critical societal roles in the advancement of knowledge and the support of sustained innovation-driven economic growth in Europe

By

Paul A David* and Stan Metcalfe**

** Stanford University & The Oxford Internet Institute*
paul.david@all-souls.ox.ac.uk

*** ESRC Centre for Research on Innovation and Competition, the University of Manchester & The Department of Economics, University of Queensland.*
stan.metcalfe@manchester.ac.uk

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1. INTRODUCTION: PURPOSES AND ORGANIZATION OF THE REPORT

Public research organizations (PROs) occupy an understandably prominent, indeed, central position in current thinking and planning about the future of the European Research Area (ERA). The term "public research organization" as it is used here includes both specialized technology research organizations (TROs), and higher education institutions (HEI's) that engage in research and development and research training (RDT) activities with substantial funding support from public and quasi-public (e.g., charitable and non-profit foundation) sources. Among the variety of PROs, the "universities" are the natural focus of this Report.[1] The character and the span of their multi-functional activities gives these institutions a critical role – not only in programs and policies that aim to advance the knowledge base for technological innovation and economic growth in Europe, but to more largely benefit the knowledge society of that region and the world at large.

In *The European Research Area: New Perspectives*, a European Commission Green Paper presented very recently [COM(2007) 161 final, Brussels 04.04.2007], university-related structures and performance characteristics are salient in three among the six features that are seen needed by the scientific communities, businesses and citizens of the envisaged ERA:[2]

(1) an **adequate flow of competent researchers who will be highly mobile** across institutional, disciplinary, sectoral and national boundaries;

(2) **excellent and properly resourced research institutions** that participate actively in
(i) effective public-private cooperation and partnerships,
(ii) research and innovation "clusters,"
(iii) virtual research communities, mostly specializing in interdisciplinary areas;

(3) **well-coordinated research programs** that include ample support at the European-wide level for jointly-programmed and jointly-assessed public R&D investments to address areas of common priority;

(4) **effective knowledge-sharing** between public research and industry, and the dissemination of research findings among the public at large;

(5) **world-class research infrastructures** that are integrated and rendered accessible by advanced computer mediated telecommunications networks.

(6**) a wide opening of the European Research Area to the world** that can engage with European partners and neighboring countries that are committed to addressing global problems.

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[1] It is convenient -- and now conventional usage (at least in European Commission documents) -- to take "universities" as a collective descriptor for tertiary educational organizations. We do so here without suggesting that in specific policy contexts one may safely disregard the important differences that exist between universities and other HEIs -- such as the *grandes ecoles*, *fachnochschulen*, *politechnicos*, and other, emerging technical research and training institutes, including the prospective European Institute of Technology (ETI).

[2] The ordering, as well as the precise phrasing of the items in the following paraphrased list is ours, rather than a quotation from the Green Paper [COM (2007,161:p. 2].

Purposes

This Report undertakes to review both the appraisals of the current state of Europe's universities, and various lines of policy, programmatic action and corrective institutional reform measures that have been advanced with the purpose of strengthening these research institutions and directing the talents of their faculties, staffs and administrators so as to better serve the needs for European society in the modern challenging environment of global economic competition. For this purpose we have drawn upon a variety of official and other sources, including selected reports and reviews prepared for national governments, commentaries and policy recommendations by university associations and other stakeholder bodies, economic research publications, studies undertaken for the European Commission, EC staff working papers, Communications, and other official documents that the staff of DG-Research kindly been brought to our attention.

The subject matter is both immense and complicated, and the pertinent literature has grown to overwhelming proportions. There can be no pretense that the material presented here is in any sense comprehensive, or that it does justice to the institutional and economic diversity of the way in which the issues examined here present themselves in the different provinces of Europe. Our goal is to provide a conceptual framework and some illuminating empirical information that highlights key policy issues and possibly provoke reflection and further critical discussion.

Organization

We begin in **Section 2** (*The HEI's in the European Research and Innovation "Ecology": A Brief View of Scale, Differentiation, Diversity, and Change*) by presenting a necessarily compressed overview of the absolute and relative quantitative dimensions of the PRO sector in Europe, the resources employed in the universities (and other HEIs), and some gross indicators of the diversity of the research and educational activities conducted by universities across the provinces of Europe. One main aim of this part of the discussion is to convey both the importance of resource allocation questions concerning the "university sector" within the ERA, while cautioning against casual generalizations that treat this sector as a homogeneous entity for the purpose of prescribing policy measures, or rendering assessments of "the universities'" performance on the basis of what may be unrepresentative observations. A second major goal is conceptual in nature: we view the region's diverse array of HEIs within the larger ecology of knowledge-using and knowledge-creating organizations with which they may interact. Taking that approach serves to highlight conditions under which the development of "innovation systems" is an emergent property of that ecology, resulting from the formation of certain mutually reinforcing inter-organizational relationships.

Section 3 *(Perceptions of Progress, Crises of Unfulfilled Performance Expectations*) examines the more concrete aspects of the universities' present situations in Europe that have attracted the attention of commentators, particularly those that have been identified as particularly problematic. We notice that underlying many recent assessments of that kind are implicit comparisons with reference standards or "benchmarks" based upon perceptions of the performance of contemporary higher education sectors (HES) in other economically advanced societies. The metaphors of "global competition" – which had gained currency during the 1980's in discussions of the intensification of business rivalries in liberalized international commodity and financial markets -- plainly has inspired the rhetoric of "crisis" that now colors many such appraisals of the performance of Europe's HEIs, and the urgency of the attendant calls for remedial action. We look more closely, and with some skepticism at the evidence that has been adduced in support of some of the more alarmingly pessimistic representations of the effectiveness of the European higher educational institutions, and of the collective international standings of Europe's academic research scientists and engineers. Proceeding in this way, we seek to identify the conditions that are truly problematic in their consequences, rather than outwardly symbolic, and which therefore deserve priority of attention in both public policy recommendations and coordinated actions by national governments, university leaders, and the architects of EU-wide programmes addressing the needs of the ERA.

Section 4 (*The Thrust of EU Policies and Practice: Promoting more direct involvement of Europe's universities in innovation*) considers whether a number of familiar and widely discussed policies and institutional reform measures that are being pursued with the intention of engaging the talents and resources of the PROs (and primarily the "universities") more fully in commercially-oriented research, are having the intended beneficial effects; and whether there are commensurate costs that should be set against those gains. Further, to the extent that the desired relationship between benefits and costs has not been realized, we consider whether prescriptions for the "modernization" of Europe's universities can adequately address the sources of the most serious immediate problems; or whether the should be seen as responding to other, longer-term concerns. This, being the longest of the sections, forms the empirical core of the Report and its discussion is structured under the following headings:

4.1 Technology Licensing as a Modus of Technology Transfer to Industry;

4.2 Technology Transfer Offices and theirPerformance in Europe;

4.3 University "Start-Ups", Ventures in Venture Capital Funding, and Promotion of Regional Development "Clusters";

4.4 Social Interactions and the Facilitation of Collaboration;

4.5 An Unproductive Tension? Rethinking IP Ownership and University-Business Research Collaborations.

Section 5 (*Policy for an Innovation System or for a Vibrant"Ecology of Innovation"?)* steps back from the specifics of the preceding discussion to suggest general frameworks for thinking not only about the contribution of HEIs not only within a "European and Research Area for Innovation," but also about the European society's broader set of knowledge-needs both in the present and in the future. From that perspective we comment on the several unresolved and in some respects irreducible tensions, the presence of which has been acknowledged explicitly by recent policy documents, including the EC Green Paper on "new perspectives" for the ERA. The questions this raises involve having to confront difficult choices between conflicting desiderata. In handling such problems one should recognize that the unavailing nature of seeking "best-practices" that promise to enhance the efficiency of resource use and thereby potentially easing the clash between visions of what is "good". That, of course, is the familiar recourse of microeconomists schooled in modern welfare analysis, but to set priorities for the design of "coherent" science and technology policy programs in a rapidly changing world requires discussion and debate about the comparative value of "ends," not only about the best "means". Moreover, even to evoke that sometimes useful dichotomy obscures the frequency with which "today's ends" can turn out to be "tomorrow's means." It is possible, nevertheless, to try to reframe the policy agenda to focus more attention on enhancing the capabilities of actors, organizations and institutions so that both individuals and collectivities are able to respond flexibly to opportunities and needs for collaboration that will bring timely, reliable and "disinterested expertise" to bear upon challenging problems of a rapidly changing environment. True, because the precise nature of those challenges often will be impossible to fully anticipate, pre-prepared portfolios of "solutions" which not contain appropriate responses, adaptability is a useful system capability, indeed a survival capability that may be learned and elaborated by the specialized agents and agencies that form "ecologies of innovation."

2. THE HEI'S IN THE EUROPEAN RESEARCH AND INNOVATION "ECOLOGY": A BRIEF VIEW OF DIFFERENTIATION, DIVERSITY, AND CHANGE

The European organizational ecology that the concept of the ERA is meant to comprehend certainly meets all the criteria for a complex division of labour in the production and use of knowledge for innovation. Publicly funded research organisations, universities and mission-oriented research laboratories, play a central role particularly in relation to the generation and dissemination of fundamental as well as mission-oriented scientific, engineering and medical knowledge, and they are complemented by more applied public sector institutes and laboratories responsible for metrology and standards. They are supported also by a wide range of privately funded laboratories, ranging from those concerned with fundamental research (the Max Planck system in Germany) to market governed, science and technology consultancy based operations that are an integral part of the knowledge intensive business services sector. In addition, and fundamentally, there are the complementary activities of firms with R&D facilities and the laboratories of other knowledge generating organisations such as research hospitals. In this division of labor, the role of firms is crucial because it is primarily firms, of all the organisations involved, who must achieve an effective synthesis of the many aspects of the innovation problem and carry it through to commercialization. This schematic view, however, masks some of the more recent changes that it is now necessary to examine more closely.

The Shifting Ground of University-Business Interactions

As of 2004 there were 1.8m million researchers in the EU(25) [defined as individuals creating knowledge, products processes, methods and systems in management of these activities] with some 873k employed in the HE sector, 700k employed in business enterprise and the remaining 195K occupied in the government., sector. R&D personnel account for 1.36% of the EU (25) labour force (source: *Eurostat*). The HES is adding new graduates at an annual rate of 13 per 1000 population, compared to 10 per1000 in the USA. Taken overall, for there are significant differences across Member States, HEI graduates comprise 30 percent of the employed workforce in the EU, and, given the composition of economic activity and the labour intensity of service activities, it is not surprising that 80% of them are engaged in the region's broadly defined "service sector".

Viewing the HES in terms of its constituent organisations, there are approximately 4000 higher education institutions across the EU, and at least 600 other public research laboratories whose activities are divided between applied and basic research and dissemination in the proportions.[3] Most PROs are directed at applied research and development work and the

[3] . See PREST, 2004 ?FULL REF?

diffusion of knowledge, predominantly in natural sciences, engineering and technology. It is notable that very few such organisations are engaged with service activities. With respect to universities and other PROs there are great differences in relative size and strategic purpose. Universities differ widely in terms of there comparative focus on research, teaching and vocational education, differences that are often reflected in the balance of disciplines included in a University's activities. Universities and other PROs differ widely also in terms of their ages. The number of public research laboratories grew rapidly from the 1930s onwards, with over two-fifths (250) of the total research centers having been created in the 1980-1990 period alone; the post WWII period witnessed a similar rapid increase in the number of universities in the Member States, so much so that by the early 1990s more than two thirds of HEIs in the EU had been founded after 1949.[4]

Indeed, it is remarkable how much innovation and structural adaptation the PRO system in Europe has experienced during the past four decades. It is certainly not the conservative backwater that sometimes is depicted by reform-minded critics. Indeed, within the constraints of public policy and limited funding, the Europe's HEIs as a group as well as individually continue to evolve, lead and respond to the challenges and opportunities opened up by new branches of scientific and engineering knowledge (bioscience, software, new materials and nanotechnology, being prominent instances), as well as by rapid growth in the numbers of students enrolled, and the conundrums posed by a broadening range of interactions with business entities and direct involvements in the creation of economic wealth from knowledge. A measure of the adaptations that are in train is provided by the vigourous contemporary debates that address the tensions between collegial and managerial modes of functioning, between alternative modes of funding, between the free and open disclosure of research results and confidentiality and the exploitation of IP ownership rights, and between appropriate modes of leadership and governance in organizations that have come to be judged more in terms of the services they provide to external clients rather than the support they given to internal research, scholarship, teaching and the curation of information resources.[5]

Of course, taken as a whole, the EU spends less on R&D and higher education than the USA. But the issue is not simply the level of expenditures; rather, it is the public/private composition of those investments, the quality of the new knowledge that is created and the effectiveness with which the new knowledge is imparted and connected in practical ways with the needs of individuals and organizations that can utilize it in dealing with societal problems, including those encountered in the business of innovation.[6] Indeed, instead of focusing on raw expenditure figures, it may be more useful to consider recent changes in the internal organisation of the ERA that are likely to impinge in one way or another on the social productivity of those expenditures.

In the past three decades the ecology of PROs and of firms in relation to innovation has changed considerably, with the following developments being of prime importance:

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[4] See A. Geuna, *The Economics of Knowledge Production: Funding and the Structure of University Research*, London: Edward Elgar, 1999, ch. 2.

[5] See Observatory of the European University (OEU) 2007, 'Position Paper', PRIME Network.

[6] See the Reports of the EC DG-Research Experts Group on Knowledge for Growth on the issues of the "R&D gap" (M. O'Sullivan) rapporteur, 2007) and internationalization of R&D (D. Foray) rapporteur, 2006.

- the general demise of centralized corporate, fundamental R&D laboratories in manufacturing industry and the reorganisation of corporate applied R&D around divisional, near to market activities;
- the increased internationalization of R&D activity as some large firms become more willing to engage with universities and TROs on a world wide scale;
- the continued increase in "knowledge based service" activities within EU GDP, with the nature and meanings attached to "R&D activities" in the service economy being quite different from those in manufacturing and other commodity producing sectors;
- the decline of defense R&D that took place with the ending of the Cold War, especially among the western European member states;
- the privatization or adoption of different governance structures for many former public mission-oriented research laboratories, defense, metrology, etc, invoking new governance structures that placed them at arms length from government;
- the emergence of new areas of science with potentially strong commercial potential, certainly biosciences, but also others such as new materials and nanotechnologies, combined with an increasing awareness that many innovation problems do not fit within single discipline boundaries;.
- a growth in the number of universities and number of students per university, combined with increasing financial pressures on university funding systems in general and the funding of university research in particular; and;

Taken together these changes represent a fundamental restructuring of the organizational ecology and the cognitive environment affecting innovation in the EU. The changing mix of market and non-market actors, the new governance systems, and new pressures on limited resources all impinge on the possibilities of forming innovation systems that may yield the desired flow of opportunities to create wealth and human welfare from reliable knowledge. To give just one example of the changing structure of innovation related activity, we point to the effect of these changes upon the growth in the outsourcing of R&D by business; some estimates suggest that 15% of corporate R&D is outsourced to PROs either as joint research projects or as research contracts to meet contractor needs.[7] It is hardly surprising, therefore, that uncertainties about the role of Europe's university system and its interaction with the business sector should have acquired great prominence in discussions of science, technology and innovation policies.

It is apparent that any critical look at the current higher education scene in the EU does raise a host of troubling questions, many of which recur in different forms and guises throughout the policy discussion of the past decade. Thus one could draw attention to the following list of difficult issues:

- Does the EU as a whole presently contain appropriate organizational ecologies, in terms of diversity, composition, and quality of its PROs, and in regard to their engagement with the innovation process – especially in of the emerging disciplinary specialities and transdisciplinary research areas?

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[7] See J. Howells, "Research and Technology Outsourcing and Innovation Systems", *Industry and Innovation,* Vol.6, 1999: pp. 111-129.

- Are a sufficient number of EU Universities at the forefront of international research, so that they can provide EU firms with a window on the best global research that is available?
- Do PRO governance systems provide appropriate incentives to reward researchers for their engagement with innovation problems?
- Are EU firms making adequate internal investments to build and maintain "absorptive capacity" in the area of scientific and engineering knowledge, and have they forged the external organisational connections that would enable them to monitor and understand the implications of the research output of PROs and engage meaningfully with the latter in the pursuit of solutions to innovation problems?
- Do sufficient specialist bridging organisations (innovation clearing houses and platforms facilitating special knowledge-pooling needs of particular branches of enterprise in specific sectors) exist, or do new ones need to be founded to serve as intermediate links connecting PROs and commercial firms in the innovation process?
- Given that some 80% of EU GDP is generated in service activities, broadly defined, does this set particular requirements for the balance of disciplinary funding in the PRO research system?
- Are different kinds of innovation system needed to adapt to the innovation needs of service firms, recognising the interdependence of many service firms on manufacturing firms and conversely?
- Given the role of public expenditure in the fields of health, education, defense (and the likely future claims of environmental amelioration efforts), is there unexploited scope for mission-oriented agencies to strategically channel public procurement expenditures in directions that will also yield innovation-spillovers in the private sector?

Needless to say, definitive answers to these questions will not be readily forthcoming, and some of these issues represent matters that have scarcely begun to be tackled by serious empirical research studies of the kind that must form the basis for policy judgments. We shall try to address this web of difficult questions in a general way within an innovation-systems framework of analysis that focuses attention on two key issues. The first concerns the nature of the ecology of knowledgeable individuals working in effective organisations; and the second deals with the conditions that are conducive to the formation of timely and effective connectivity among those individuals for the purposes of solving specific innovation problems.

From Ecologies to Innovation Systems: A Conceptual Framework for Policy Development

It may be useful to think of the set of innovation related organisations as constituting innovation ecology, for it is not of itself a system for innovation. Rather it provides the basis from which particular innovation systems focused around particular problems can either self organize or, failing this, be deliberately encouraged to form by specific policy interventions. The defining characteristics of a system require that its components are connected for different purposes, and, the possibility of multiple patterns of connectivity implies that any given ecology of components can be formed into very many different kinds of innovation systems.[8] In innovation ecology the scientists and technologists are key actors, for they are

[8] J.S. Metcalfe, "Innovation Systems, Innovation Policy and Restless Capitalism", in F. Malerba and S. Brusoni, eds., *Perspectives on Innovation,* Cambridge, Cambridge University Press, 2007.

able to readily access and produce requisite knowledge for one (technical) kind of creativity. Clearly, the organisational context in which they work, and the structure of the institutionalized incentives and constraints that those organizations provide, play a crucial part in influencing the pattern of their interactions (and potentials for "connectivity") with other agents, as well as the productivity of their activities.[9] The policies and practices of the organisations in which they carry out their work and the wider political and social climate consequently are a powerful shaper of their propensity to interact across the research system in general and with business firms in particular. Institutions such as the legal regime protecting IPR, the policies of firms vis-à-vis employee inventors, and the specific reward and career progression norms that apply to those following academic careers, all contribute to shape expectations on the part of those working in PROs regarding the payoffs from interacting with firms and other non-university organisations. How this ecology is organized and the incentives and barriers for different elements to cooperate in the pursuance of innovation are central issues for study in the design of an empirically and analytically informed innovation policy.

In a healthy European Research Area there would be countless numbers of specialised innovation systems generated at the micro level, systems that are born and decay as new innovation problems are posed and solved. The notion of a single, monolithic and highly durable innovation system is a deceptive intellectual construct for policy-makers to embrace. Instead, it would be far better to recognise the multiple ways that firms and PROs interact to further the innovation process. As we argue (more fully, in Section 5 below), European innovation policy seen from this perspective has two dimensions of responsibility: one should undertake to ensure that the ecology of research organizations is sufficiently rich and diverse that all areas of relevant knowledge are covered by European expertise; and, a responsibility to frame the institutional architecture and the structures of regulatory constraints and rewards available to present and future researchers in a way that allows sufficient flexibility and modifications that stimulate and reinforce the connections that transforms the ecology into adaptive innovation systems. Keeping track of the formation and dissolution of the myriad innovation systems may emerge from the ecology organizations in the ERA may well be impossible. Furthermore, it seems increasingly likely that the constituents of a relevant ecology to solve a particular innovation problem will lie beyond the EU's political borders, making the monitoring task still more difficult. Neither of these observations, however, should occasion worry on the part of public policy-makers.

If innovation systems are fluid and are constructed around specific innovation problems, then it is readily seen why firms, as the primary organisations that bring innovations into economic effect must play a central motivational role in the construction of innovation systems. Innovations are not to be equated with inventions, and their achievement, too, requires accessing and combining many more kinds of knowledge and capability than are summed up by the phrase "science and technology." Knowledge of markets, of organisations, and of the availability of factor inputs are key aspects of innovation, and their absence the downfall of many a promising invention's transformation into a successful product or process. This underscores the significance of the division of labour and a prerequisite for the development of expertise in the process of innovation, and the fact that PROs by and large are preoccupied with expertise in scientific and technical knowledge creation and diffusion.

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[9] D. Foray, *The Economics of Knowledge*, Cambridge MA, MIT Press, 2004.

A division of labour implies organisations that specialize, and as a consequence will create boundary problems that can impede interactions with other organisations. Moreover, PROS are not the final actors in the innovation process so their contribution to wealth creation through innovation is indirect and partial, and depends on effective connections with the business enterprise system. This is not to belittle their importance; rather it is meant to emphasise the complicated nature of the innovation process and the difficult task the innovating firm faces in accessing and combining the multiple kinds of knowledge on which innovation depends. Innovation problems rarely fall entirely within single disciplinary boundaries and it is this fact that underpins the concern for a growth in trans-disciplinary research activity. This issue is highlighted in the *Lambert Review* of university-business interactions in the UK,[10] for example, where the increasing complexity of technologies is pointed to as a factor forcing companies to develop their external knowledge connections if they are to innovate competitively. How connectivity and bridging between universities and firms is to be stimulated is indeed the policy question of the moment. Successful answers depend on recognising that firms and universities (PROs in general) are very different kinds of organisations that have been designed, as it were, to fulfill very different economic purposes and societal functions. Thus critics of the role of universities and firms in respect to their performance in commercializing research results and exploiting the income-generating potential of the "knowledge assets" represented by their faculties and staffs, should reflect first on the fact that the division of labour been profit seeking business corporations and universities has not developed by chance. Instead, the persistence and co-existence of each as a distinct organization form reflects both the quite distinct roles that these organisations fulfill, and, moreover the complementary between those roles in sustaining the vitality of economies and societies that preserve and encourage the development of their functionally specialized capabilities.[11]

Recognition of the main features of this division of labour is hardly new. Alfred Marshall in his *Industry and Trade* (1919) sketched the main features of what we would now call an innovation system by distinguishing different kinds of research laboratory, each type full filling a different role in an economy's knowledge ecology. The ecology is articulated in terms of a tripartite classification of research laboratories, as follows: those of the first order, charged with extending knowledge in the large and normally the province of publicly funded universities those originators of scientific advances that revolutionise the methods of industry; those of the second order, charged with generating knowledge directed at the requirements of a particular branch of industry and organised either by single giant businesses or in collaborative association between businesses; and those of the third order, quality control laboratories for particular establishments that check that their output meets the standards required.[12] As with any division of labour, the functioning of the resulting system

[10] *The Lambert Review of University-Business Interactions*, HM Treasury. London: HMSO (December) 2003.

[11] This general point, regarding the productive co-existence of distinctive organizational forms whose specialized functions are complementary at the (innovation) system level, is developed concretely (at the end of Section 4, below), in regard to the socially beneficial organizational separation between the innovating business firms' primary reliance on combinations of secrecy and the proprietary regime of R&D supported by IRP protections, and universities and publicly supported civil research organizations hosting communities engaged primarily in exploratory and mission-oriented research conducted largely in accord with the norms of "open science." .

[12] Today we would include in the latter category the metrology laboratories and public or quasi-public "standards institutes" charged with setting and disseminating physical and technical standards, and checking compliance of products with specifications mandated by government regulations.

of production depends on how the specialized components are interconnected in this case, not by arms-length anonymous market transactions, but by personal scientific contacts and common reference to published bodies of highly codified information. Thus, the technical research laboratory of an industry benefits from keeping in touch with the chief scientific laboratories, and "the later may gain much and lose nothing" by keeping in touch with the industries whose methods may be improved by the fruits of fundamental research. Marshall's thoroughly modern account of the innovation processes therefore is one in which advances in knowledge are made by different actors, having differentiated capabilities and specialisations, working in different kinds of organisation with different motives and distinctive methods. The businessman as innovator is supported by the role of students, "men who labour not with reference to the attainment of any particular practical end, but in search of knowledge for its own sake."(*Industry and Trade*, II, 2, 203) Further, Marshall suggests that disinterested pursuit is generally richer in its societal and economic outcomes than knowledge that had been pursued for particular private and practical ends.[13]

What Marshall doesn't tell us is how their different objectives and modes of functioning, funding and organisation, may encourage or inhibit the coordination process, other than to suggest that this is a growing commonality of interest and consequent collaboration between science and industry at the borderland between science and technique, which can perhaps be aided by public support. The problem of designing such inter-organizational connections and coordination of efforts in the sphere of information production and exchange that is relevant for innovation, a challenge that so preoccupies modern governments, remains one on which there have not been great advances since the time of Marshall.

The insight that the innovative performance of firms might depend upon the way in which they build an external organisation of connections with universities and other laboratories suggests that university industry interactions in pursuit of business experimentation are not simply a product of the past two decades. This is well understood in relation to university industry interactions in the USA, but it applies as much to Europe.[14] Indeed, to provide just one example out of many, Horrocks has shown how a Department for Industrial Chemistry was established at the University of Liverpool in 1926 and followed a fundamental research programme in the chemistry of oils and fats that was of direct practical concern to major chemical and food processing firms in the region, one of these firms being Lever Bros. However, in 1929 that company became part of Unilever, and the merger and the subsequent refocusing of the R&D strategy and relocation of the research laboratories of the new company to the Netherlands and Germany served to break the ties with Liverpool University.

[13] A modern counterpart of this Marshallian perspective is found in the economic analysis of the mechanisms through which exploratory investigation of physical phenomena, and the development of abstract analytical methods such as those of mathematics – sometimes casually referred to as "basic research" –indirectly creates economic payoffs through the "spillovers", or externalities of their findings, that raise the private and social marginal rate of return on R&D investments that are commercially-oriented (so-called applied research). For illustrative discussion of the workings of such mechanisms, see P. A. David, D.C. Mowery and W. E. Steinmueller, "Analyzing the Payoffs From Basic Research," *Economics of Innovation and New Technology*, vol. 2 (4), 1992, pp. 73-90.

[14] On the USA, D.C. Mowery, R.R. Nelson, B. Sampat, and A. A Zeidonis, 'The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Bayh-Dole Act of 1980', *Research Policy*, Vol.30, 2001:pp. 99-119 ; on Europe, Murmann 2004; also R. R. Nelson, 'The Market Economy and the Scientific Commons', *Research Policy*, Vol. 33, 2004:pp. 455-471.

Indeed, the Department in Liverpool was closed in the early 1950s, by which time its external support network had largely disappeared.[15]

Because scientific researchers face strong incentives to place their findings in the public domain such information is readily accessible to firms that have the requisite scientific capability. But these spontaneous processes of interaction do not exhaust the possibilities, nor do they necessarily address all the dimensions of the innovation process. If the transfer of knowledge from PROs to business could be fully and efficiently achieved through placing knowledge in the public domain there would be little need to consider the matter further; managers of innovation need only "read the relevant literature". This they do, but the issues are far more subtle. Not all of the knowledge possessed by scientists is placed in the public domain, and the unexpressed (tacit) components of knowledge matter critically in translating a generic scientific discovery or technological result into a specific commercially viable application.

To gain access to such knowledge, co-location and personal interaction are important mechanisms, so geographical distance often plays a potent role in shaping the nature and prevalence of such transactions.[16] The organisation of conferences and workshops to foster personal connections is thus an important part of the contribution universities can make to the formation of innovation systems. Moreover, the capacity to understand what others know requires prior investments in capability. Information is in the economist's parlance, a "public good, which implies *inter alia* that the incremental cost of its reproduction is negligibly small and the benefits of its utilization can be concurrently enjoyed by many. But the fixed costs of initially creating information are often substantial, especially in relation to the incremental costs of sharing it. In that sense it is far from a "free" good. Nor is the capacity to decode and interpret information and transform it into the human capabilities that we call "knowledge" acquired costlessly.[17]

Consequently, as has been pointed out already, a firm must invest in the development of its own "knowledge base" – and the information resources that both support and flow from that collective capability; it must therefore create the external organisation connections and the capability of knowing what questions to ask, and who address them to, and how to interpret the answers in the resolution of its innovation problems.[18] . This can pose an obvious problem for the connectivity of innovation systems, namely lack of business R&D or of qualified employees to enable firms to interact in a high quality way with PROs. That is why it is important to increase business R&D investments and the commercial employment of QSTs as a complementary policy measure accompanying any increase in public R&D outlays, as is

[15] See S. M. Horrocks, 'Industrial Chemistry and its Changing Patrons at the University of Liverpool, 1926-1951', *Technology and Culture*, Vol.48, 2007: pp.43-66. Examples of this kind can be produced almost at will: military R&D needs have played a large role in this respect, but so have the links that electrical and chemical companies focused on commercial market believe it was useful to develop with particular individual academic consultants and university-based research institutes.

[16] A. Arundel, and A. Geuna, 'Proximity and the Use of Public Science by European Firms', *Economics of Innovation and New Technology*, Vol.13, 2004: pp. 559-580.

[17] We take the view that information should be distinguished conceptually from knowledge, the latter being a mental capability of individuals that cannot itself be shared with others, whereas the information that it may to used to encode for transmission has the properties of public goods, as noted in the text.

[18] Rosenberg, "Why Firms do Basic Scientific Research (With Their own Money)", *Research Policy*, 1991; B.-A.Lundvall et al., *National Systems of Innovation*, 1992.

recognised in the EU Barcelona targets. Increasing public R&D without a commensurate increase in private R&D will severely limit university and industry interactions that can utilize the results of the former in pursuit of innovation.

Recent investigations that have drawn attention to the role of innovation intermediaries have deepened our understanding of the processes through which innovation systems emerge. These intermediaries typically are specialised research laboratories (some of which are privatized former public research laboratories or industry research associations) that have accumulated expertise in transfer sciences and the industrial technologies into which the latter feed.[19] It is precisely because information does not flow easily between unlike minds that such agents are able to play important (and profitable) roles in Europe's innovative activities: variously called bridging organisations, technology brokers or boundary organisations, they serve not only serve to connect different components of innovation systems in responsive mode, but also perform pro-actively, by animating new connections that might not arise spontaneously.. As exemplars of Marshall's third type of laboratory, they provide a vast array of information and consultancy-based services, ranging from foresight exercises, to testing and quality accreditation, cross disciplinary information integration and recombination for the identification of new potentially profitable areas of commercial product design and development.

We might reasonably conclude from the evidence that university-industry interactions are a normal part of innovative activities, that they arise spontaneously, that they form and reform over time, and that they are of many different kinds but that, importantly, they will only occur where the firms in question have an internal capacity to engage with universities and other PROs. Connectivity is dependent on a capacity to communicate to ask fruitful questions and understand answers. This broad conceptualization of "connectivity", however, covers a very wide range of phenomena reflecting the specific nature of the innovation problems that command attention. One should add, of course, that it is of little purpose for the firm to be open to external interaction if the relevant PROs are not also open.

But it is no less important to make the point that many of the connections forming an innovation system are the outcome of market processes, and normal trade links with suppliers and customers and competitors. PROs constitute only part of the web defining any specific innovation system. In relation to market processes and innovation, the openness of product markets to invasion by new products/competitors is obviously crucial as an incentive to innovation and in terms of the opportunity to innovate. While competitive markets often are appraised in terms of their functionality in securing an efficient allocation of resources, this is not their prime advantage in modern capitalist economies. Rather, it is their openness to the entry of innovators, and the forces that they bring to bear on firms that are slow to adapt to changing market and technological opportunities – giving them the power to bring about alterations in the allocation of resources and expenditures in response to innovation, that constitutes the true power of the competitive market mechanism.[20]. Factor markets play an equally significant role, so, for example, the existence of supportive capital markets that will

[19] J. Howells, "Intermediation and the Role of Intermediaries in Innovation", *Research Policy*, vol.35, 715-728

[20] See R. R. Nelson, "Assessing Private Enterprise: An Exegesis of Tangled Doctrine", *The Bell Journal of Economics*, Vol. 12, 1981: pp. 93-111; and R. R. Nelson, "Capitalism as an Engine of Progress", *Research Policy*, Vol.19, 1990: pp. 193-204. The suggested difference in effects is sometimes reduced to the distinction between the achievement of static efficiency and if dynamic efficiency in resource allocation, the latter being more relevant for innovation-driven economic growth.

fund high risk start up and early stage innovation experiments is rightly pointed to as being of crucial significance to innovative performance. Small firms, in particular do not have the luxury of the business man's traditional source of capital for innovation, a stable revenue stream.

Three facts about the nature and functioning of PRO-business relationships seem to recur in empirical studies, namely[21]:

- The principle knowledge connection between firms and universities comes from the employment of graduates, and particularly qualified scientists and technologists (QSTs) who have the technical knowledge to contribute to the solution of innovation problems;

- The connections that are market process-mediated are far more important to firms' innovative activities than are their links with the PRO system. Universities as sources of innovation problem solving are relatively low in their importance compared to, for example, links with customers and suppliers Connections with the PRO system are achieved in a multiplicity of ways so, no doubt depending on the nature of the innovation problem in question, there is no single model for these interactions). The modes of connection range from informal contacts, access to published literature, attending conferences, recruitment of graduate QSTs, temporary exchanges of staff, contractual commitments in the form of joint and open ended research programmes, and contracts to deliver specific information related to particular innovation problems.

All of these processes for coordinating the innovation division of labor are well established and operate with various degrees of efficacy. They reflect the obvious fact that human interaction is a principal mechanism for exchanging information and solving problems and that the organisational rules in which individuals work strongly shape the possibility of interaction. It is these processes of interaction that transform the knowledge ecology of an economy into an innovation system, although this is not necessarily best thought of as "a national system". The ecologies of organisations and rules of the game certainly are shaped by political and judicial processes that render them national in character, but because such ecologies are conceived of here as 'fields' that have 'potentials' that shape the formation of innovation systems, it does not follow that the latter systems themselves will be national in character. Their systemic character arises from the modalities of interaction noted above and the resulting connections that are formed in the search for solutions to specific innovation problems. In many cases these connections will draw on different national knowledge ecologies and they may exhibit strong sectoral differences.[22]

It may thus be fruitful to consider the idea that the dynamic behind the self-organisation of innovation systems is closely connected to the sequence of problems associated with any particular attempt to innovate. If so this suggests that the innovation systems so formed are transient, and that they evolve, in terms of their members and networks of connections, with the evolution of the set of related innovation problems. Thus, when considering the situations and expected roles of the universities and the PROs more generally, within the national and

[21] In relation to the second bullet point consult Gibbons and Johnson, and Yale Survey, Hughes, 2006, and in relation to the third, Hughes, 2006 and P. Mueller, "Exploring the Knowledge Filter: How Entrepreneurship and University-Industry Relationships Drive Economic Growth', *Research Policy*, Vol.35, 2006 :pp. 1499-1508.

[22] See the essays in F. Malerba, *Sectoral Systems of Innovation*, Cambridge, Cambridge University Press, 2004. .

regional "innovation-system" or "innovation systems" of the European Research Area, and equally when evaluating the extent and quality of those institutions interactions with businesses and other organizational entities, it is useful to draw from the above discussion several points of reference. These three constitute "guiding themes" that shape much of the discussion in the following sections:

(a) One should not presume there is a functioning "innovation system", but recognize instead that the latter may be – or may fail to be an emergent property of the ecology formed by these differentiated institutions and their respective actual and potential capabilities, including the array of adaptive capacities for forming mutually productive interactions with one another.

(b) Whether that functional "systemic property" is emergent, or fails to yield a sustained process generating and diffusing technological and organization innovations that enhance the region's economic capabilities and the welfare of its citizens, should not be viewed as determined only by the characteristics and performance qualities of some particular class of institutions within the ecology. This applies to assessments of the "responsibility" of the research-performing organizations of Europe's economy for the latter's innovative capabilities and macroeconomic performance. In the present context, the same proposition should be applied when diagnosing the degree to which responsibility for the collective functioning of the research organizations within the ERA can properly be laid at the door of the universities and other PROs.[23]

(c) Numerous contemporary commentaries and recommendations that issue both from within the academy and from other quarters of European society and polity, remain concerned by, and anxious to act upon the perception that there are serious deficiencies in the present state of the region's universities which must be having correspondingly serious detrimental effects upon the economic performance of the EU's constituent regions. But, the identification of those structural defects and of their systemic implications is neither straightforward nor certain. Unfortunately, the conduct of difficult causal analyses often is dispensed with and replaced by comparisons casually drawn from other parts of the world -- places where things appear to be done differently, and where the outcomes emerging from those distant environments appear more satisfactory than those experienced closer to home. International, and inter-organizational comparisons certainly do deserve notice, for, they can be usefully suggestive of phenomena that bear closer scrutiny. Comparative institutional analysis, however, is a tool that requires careful use, with due attention to the full contexts, including background conditions that will not always seem relevant to the analyst's focus of

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[23] See the perspective elaborated by P. Aghion, P. A. David, and D. Foray, "Linking Policy Research and Practice in 'STIG Systems': Many Obstacles, but Some Ways Forward," SIEPR Policy Paper (October) 2006 [available at: http://siepr.stanford.edu/papers/pdf/06-09.html]. Other recent contributions to the literature on economic development by leading macroeconomic theorists (e.g., P. Aghion and P. Howitt , "Appropriate Growth Policy: a Unifying Framework, the 2005 J. A. Schumpeter lecture, 20th Annual Congress of the European Economic Association, Amsterdam,2005, C. I. Jones, "The Weak Link Theory of Economic Development," U.C.Berkeley Working Paper, (February) 2007 [available at: http://econseminars.stanford.edu/papers/allpapers/links.pdf] emphasize the range of empirical evidence that militates against reliance either upon "key policy" interventions, or comprehensive programs aspiring to address inventories of "priorities for sustainable development." As the replacement for both "magic bullet" and "scatter-gun" policy thinking, they would recommend more evidence-guided strategies focusing on the repair and reinforcement of "weakest links" in chains of complementary interactions that characterize successful developmental transformations. In this application of the metaphor, however, the location of the weak-points is not so much a fixed and inherent characteristic of the links themselves as it a mutable feature of the entire chain.

attention. Neglect of such care is a recipe for misunderstandings and ill-considered commitments to policy prescriptions that prove ineffectual, at best.

3. PERCEPTIONS OF PROGRESS, CRISES OF UNFULFILLED PERFORMANCE EXPECTATIONS

The EU contains PROs of many different kinds with some of them that are internationally recognized as "world class" contributors to fundamental research and education across a wide array of disciplines, but many more that are specialized, restricted in their scope and focused on maintaining competent performance in meeting the needs of their particular regions and locales. This hardly is a state of affairs that is peculiar to the HEI sector of so extensive a territory as the EU. Indeed most national tertiary educational systems exhibit marked stratification of their component institutions in terms of scales, and the quality of both their resource inputs and their performance. In the USA, a comparably large geographical domain, for example, there are c. 3000 institutions at the tertiary education level, but 100 of them are collectively the recipients of essentially all of the federal government fund allocated for university-based research projects; moreover, the top 20 research universities, divided about equally between state universities and private institutions perform more than half of the federally funded research.[24] That there is a complicated division of knowledge labour should come as no surprise at all, but should also warn us of the dangers of too facile generalisation.

The HEI Sector in Transition: Malaise or Purposeful Adaptation

All of these problematic aspects of the HEI sector, chronic under-funding, increased student loads, different degrees of centralized command and control, curriculum changes to adapt to needs and backgrounds of student bodies that in many locales are increasingly drawn from distinct provinces in Europe, and the demands of new missions to create wealth from knowledge are reshaping the European university ecology in complex ways. But these also represent competing demands and distractions that tax the attention, energies and limited material resources of university faculties and administrations. This must call into question the ability of many if not most of these institutions to respond in the near term to the call for it to make major contributions that would address Europe's present "innovation challenge."

In broad summary, the key aspects of the current situation characterizing the Europe's "HEI ecology" appear to be these:

- Universities are of many different kinds, size and scope in terms of the range of disciplines that they provide for, and they also differ very widely in international reputation. The concern is that too few contain scholars of world standard and thus

[24] This refers to the 100 research institutions belonging to the Carnegie (Foundation) "group I", there being another 100 "(Carnegie- II" research universities which are dependent upon state funding and private foundations for research support. Many of the "state universities "at the top of the federal funding distribution are in effect university systems, having multiple campuses--among which the largest in number is University of California, with Berkeley, UCLA, Santa Barbara and six others. There are, it should be noted, a number of highly respected private liberal arts "colleges" that do not offer graduate degrees, but which are very selective in their undergraduate student intake, and whose faculties include distinguished scholars, but is rare for them to be engaged in the physical sciences of engineering.

deny European firms access to the best knowledge that is available in pursuit of innovation;

- Universities undertake 80% of basic research and employ a third of all researchers but they in addition they have a major educational mission: during 2003 some 16.5 million students at all levels were rolled in the innumerable different degree programmes that were offered at almost 2000 universities in the EU..
- The scale and the performance of different national educational systems varies greatly across the EU in terms of number of students and average length of degree course, drop out rates (40% across Europe as a whole), forms of funding, levels of tuition fees selectivity of entry and progress once admitted, relative importance of public funding, and mechanisms for the allocation of research funding.
- Much is often made of the fact that, on average, the EU spends 1.2% GDP on Higher Education, compared to 2.6% in the USA. The difference, however, is due largely to the greater role of private funding in the later. Moreover. If the EU is to raise it's funding of the university system to comparable USA levels, this is not likely to come from the Member States, and in the absence of private charity recourse will have to be made to student fees and or the creation of private universities. In Poland, for example, over 250 private HEIs have been created since 1990, accounting for almost 30% of the student intake.
- The Bologna harmonisation process is imposing major structural reform on EU degree systems with the widespread adoption of a comparable degrees based on a two cycle model of undergraduate and masters' degrees, from which doctoral studies may follow.

The HEI Sector in Transition: Malaise or Normal Adaptation

All of these problematic aspects of the HEI sector, chronic under-funding, increased student loads, different degrees of centralized command and control, curriculum changes to adapt to needs and backgrounds of student bodies that in many locales are increasingly drawn from distinct provinces in Europe, and the demands of new missions to create wealth from knowledge are reshaping the European university ecology in complex ways. But these also represent competing demands and distractions that tax the attention, energies and limited material resources of university faculties and administrations. This must call into question the ability of many if not most of these institutions to respond in the near term to the call for it to make major contributions that would address Europe's present "innovation challenge."

Much literature has been devoted recently to the higher education malaise. Thus, a recent EC report[25] has concluded that "Universities in Europe find themselves at a critical juncture" one that requires weaknesses to be addressed without undermining their crucial societal role. Representatives of the administrative leaders of Europe's research universities[26] are more than conscious of the multiple pressures upon their typically strained financial resources, arising from political commitments to mass higher education, ageing and inadequately equipped lecture theatres, classrooms and laboratories, and the insistent calls for them to improve their comparative standing among the world's leaders in fundamental research while

[25] EU Commission *European Universities: Enhancing Europe's Research Base*, DG for Research Science and Society, May 2005.

[26] See, e.g., League of European Research Universities (LERU), *Universities and Innovation: the challenge for Europe*, Leuven: LERU (November) 2006.

also taking on new and unaccustomed participation in the process of technologically based business innovation.

The response to the very rapid and fundamental changes in the international environment and the European educational and research scene that has been forthcoming from relevant European national ministries of science, technology and education, and from regional agencies alike, has been rather specifically focused in urging universities to meet the latter, newest set of societal demands. Not surprisingly, those responsible for the leaders and securing support for those institutions have been attentive, sensing that the larger financing problems are not likely to be addressed by their national government if they the appear recalcitrant in accepting this additional challenge. As a consequence, within the last two decades there has crystallized a widely accepted delineation of the "Third Mission of the University" – viz., to add the pursuit active institutional strategies and practices that would facilitate the commercialization of the knowledge and technical expertise of their faculty members to the traditional roles of providing education (now increasingly construed as "training" for employment-relevant pursuits), and supporting scholarship and research.

This trefoil policy-assignment is becoming the routine context in which the strengths and deficiencies of the European University system and its parts are appraised by both national government "reviews" and European Commission studies,[27] but it is to the newest of the leaves that greatest attention tends to be directed. The alleged deficiencies typically include, under-funding of applications-oriented programs and projects, outmoded institutional governance systems and regulations that impede the formation of university connections with sources of funding support in the corporate business sector, barriers to collaborations among HEIs across Europe, incentive systems that fail to promote academic researcher's interactions with the business firms, excessive curricular emphasis on disciplinary-based teaching and research when the perceived need is for greater trans-disciplinary attention to concrete problem-solving. In short there is a pervasive concern that the University systems of the Community are too out of date and need modernizing if they are to fully contribute to Europe's drive for more growth and employment generation.[28]

Yet, any appraisal of the higher education sector's research performance, and its contributions to the commercialization of technological innovation, must start by recognising that there are wide differences in the scale of such activities across the provinces of the EU, and corresponding variations in the relative importance of the sector as a performer of public R&D expenditures. *Eurostat* data for 2005 [see ANNEX Table 1] show that the share of GERD performed in the HEIs averages about 22 percent for theEU-25 aggregate, which is roughly 1.6 times higher than that in the US and Japan. While the EU-25 level that is closely matched by an number of western European nations (Sweden, France, Belgium and the UK, with Finland and Slovakia coming in just a bit below it, there is a wide intra-EU range of variations in the statistic for other member states – from 55% in Lithuania to 10% in Romania and Slovenia. Basically, this pattern reflects the fact that where the R&D capabilities of the business sector are stronger, and a larger proportion of total R&D is performed by private organizations, the proportion of public R&D conducted outside the higher education sector is similarly greater.

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[27] EU Commission: *Mobilising Brainpower in Europe*, COM(2005)152final.

[28] EU Commission: *Delivering on the Modernisation Agenda for Universities*, COM(2006)208final.

One cannot draw from such figures any implication that the universities are in some sense the "residual" performers of public R&D in the EU, so get a larger share of the publicly funded work where the R&D performance capabilities of corporate labs is limited.[29] Nevertheless, there are indeed grounds for believing that all is not well, and perceptions of this has been sharpened by the reports of national and regional reviews the have been undertaken at the behest both of government bodies and associations of universities.[30] The report presented by LERU, the League of European Research Universities (2006: p. 1) faults Europe's universities for their deficiencies -- "with notable exceptions and national variations" – in meeting the required international standards in *quality*, in *diversity* and in *the innovation processes that exploit new knowledge and highly trained people* to be "effective and efficient:

> *In quality, the level of investment in universities is low by international standards, and funds for basic research are spread too thinly, severely disadvantaging centres of excellence compared with our principal international competitors.*
>
> *In diversity, there has been excessive convergence towards a single model of the basic research-focused university, undermining the potential for some universities to take on a more powerful regionally-focused role.*
>
> *In innovation, there has been a relative failure to exploit the existence of many parts of the research and educational capacity of the university system, particularly in comparison with the USA, and potentially compared with developing Asian economies.*

There are in this some germs of proposals that could be worth examining, such as the idea that if there were to be a rise in the aggregate volume of outlays devoted to funding public sector research, it might also be more concentrated on selected universities. What that leaves unaddressed, however, is the implication that the resulting increase in "diversity" (reflecting more pronounced inequalities in funding) might well leave many institutions with at best the same resources to fulfill their "more powerful regionally-focused role." In other respects the assessment appears to have gone rather too far toward painting a dark picture of deficiencies that are meant to be alarming – and therefore "must be remedied as a matter of urgency." A careful skeptical reading is in order on such points. If it is a problem that funding is too limited to build many centres of excellence, it is not clear that the condition is the fault of the institutions and can be remedied by them without external assistance." If a vibrant innovation

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[29] On reason is simply that patterns of government funded research vary considerably from country to country – defense R&D, for example, being relatively more important the larger western European countries than elsewhere in the region – although nowhere approaching its relative share in US.

[30] The essentials of all of the problems identified had been set out previously in the EC *Communication from the Commission: The role of the university in the Europe of knowledge*, COM(2003) 58 final. Brussels: Commission of the European Communities (5 February), 2003. For examples of national, and non-official reviews, see, for example, *The Lambert Review of University-Business Interactions*, HM Treasury. London: HMSO (December) 2003; Universities U.K., *Submission to the Lambert Review of Business-University Collaboration*, April 2003; Lambert and Butler (2006); S. Richert, Management at European Universities, Brussels: European University Association, 2005; League of European Research Universities (LERU), Universities and Innovation: the challenge for Europe, Leuven: LERU (November) 2006. In France, an account in *Le Monde* critical statements contained in a report on the "valorization" of public research investments -- released by the Inspector General of Finances, Education and Research National Research – declared that the previous 15 years had seen "little progress" following the Law of 1999 that facilitated patenting of public research results. This ignited a public outcry, and subsequent moderation by *Le Monde* of its characterization of the Inspector General's findings. See *Le Monde*, 16, 22 January 2007.

process has not emerged, is this due to something that has gone wrong in the universities and can be remedied by altering their incentives and governance structures? To chastise the entire system for not meeting the highest international quality standards – and this is not the only document of the kind that decries the fact that Europe's universities are not "world-class – is vaguely reminiscent of the wish that all the town's school-children would perform "above average".

The widening acceptance in educational and research policy discussions metaphoric references to international sports "league tables" (a particular predilection of UK commentators) is unfortunate, at best. HEIs are not football teams, nor are specialized institutions all playing "the same game," let alone according to the same league rules. Moreover, "the league" is an external construct whose ranking criteria are not necessarily relevant to the "missions" that EU universities are expected to fulfill by informed evaluators. Most rankings that purport to summarize the comparative strengths of universities involve some arbitrary (and undisclosed) scheme of weighting and aggregating their performances in a number of dimensions.[31] The resulting scoring systems tend to be biased against younger, smaller, more specialized institutions, and in favor of larger universities that are able to achieve international recognition of faculty research across a wider range of disciplines.

But is it even clear that the label "university" has been applied consistently across countries whose institutions are entered by the statisticians into these ranking contests? Moreover, one may well question the tacit assumption that very large institutions that fulfill the criterion of providing co-located multi-disciplinary expertise represent the standard of "excellence" – as distinct from international salience – that individual HEIs and policy-making throughout the European HES should be striving to achieve in the 21st century? In previous epochs where the transportation of people and the reliable transmission of messages was slower, less reliable and more costly at the margin than it has become, and will continue to become in the information age, there was a compelling economic logical to academic agglomeration. Co-location and opportunities for drawing expertise from multiple disciplines remain important in creative work and innovative problem-solving, but it is questionable whether the real economies of scale and scope at universities continue to outweigh the effects of increasing distraction, congestion and managerial complexity as one proceeds all the way to the top of the observed distribution of institution size and disciplinary coverage.

The meaning and the pertinence of references to such "league table" rankings in assessments of HEIs as providers of educational instruction, and *a fortiori* as constituent elements of emergent innovation systems in Europe, are therefore far from self-evident. Yet, their use may have merit if only in precluding recourse to still more dubious bases for judging the comparative merits of universities, of and research universities in particular. For example, an institution's relative capacity to generate foreign exchange earnings by charging overseas students high tuition and residence fees is one such criterion of "university excellence" that appears recently to have been gaining adherents in surprising quarters, and, not surprisingly, yielding some bizarre policy recommendations.[32]

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[31] Do European educational policy-leaders who express dismay that there are 30 U.S. research universities that are more highly ranked than the Sorbonne, which stands 46th from the top in the Shanghai Jaio Tong index of "world-class" universities, really know and agree with the relevance of the criteria that yielded that ranking?

[32] As one of the more flagrant instances of the new trend to evaluating universities' comparative contribution to society by reference to their "wealth-creating" role in the national economy, consider the recommendation advanced by Peter Knight, former Vice Chancellor of the University of Central England in Birmingham (Peter Knight, "Some universities are better than others," *The Guardian*, 22 May, 2007 – Education Guardian section,

The 2007 EC Green Paper: *The European Research Area: New Perspectives* (p.14) succinctly synthesizes and summarizes several of the main critical perspectives that have emerged during the past five years in assessments of prevailing overall condition of Europe's higher education sector affecting its scientific and technological research capabilities. It is noted that while universities and other PROs together perform more than 35% of all research undertaken in Europe, their potentials as a source of fundamental research and applied research that would business investments in R&D and innovation are remaining less than "fully realized." But it then passes beneath the surface symptoms to identify some of the sources of this failure. "Dispersion of resources"--resulting in lack of regional and institutional critical mass needed to pursue and achieve breakthroughs in key fields, "insufficient links with business and society," and "rigidities" in regulations and governance structures, are indicted as key structural problems responsible for under-performance.

The Commission Staff Working Paper [COM(2007) 412/2] -- accompanying the recent Green Paper on the ERA, has offered some quantitative evidence in substantiations of the position that Europe's higher education sector, and its research universities in particular are not meeting the "international competition," which here is taken to be the U.S. The table reproduced here as ANNEX (p.4) presents "field-weighted citation impact scores" for scientific that show "the EU-25 still lags significantly behind the US in terms of impact of its scientific output. They also tend to demonstrate that in this regard there hasn't been any improvement compared to the US in the overwhelming majority of scientific disciplines since the mid-nineties." Another indicator [ANNEX (p.3)], focusing on the distribution of national scientific contribution to the most frequently cited papers, find that while the EU-25's collective contribution to the (top 10%) high-impact publications that corresponds more or less to what is to be expected given the region's publication output, it lags well behind the US contributing to papers that among the most highly cited.

Evidence of this kind should be treated with caution. It shows something, but what these data signify may be artifacts of their sources: for example, the bias of the archival collection of journals towards English language papers is a consideration in comparisons with the US. Further, although it is true that in aggregate the number of 'nominal' researchers in the EU

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p.4): "'Top' or 'world-class' ranking must come for a martketplace where competition is red in tooth and claw. In higher education, this is the recruitment of international students and the level of their fees." The writer's contention is that "top universities are the academic equivalent of Gucci or Beckham, and should market themselves on that basis," because what foreign students are willing to pay high fees to "buy" is "that most elusive but pervasive of modern commodities: a brand name." Indeed Knight goes so far as to suggest (perhaps, tongue-in-cheek) that it doesn't really matter what "top brand" university's like Oxford and Cambridge actually teach, presumably because their brand's prestige rests on the demonstrated willingness of students to associate themselves with it—and with the others who similarly can afford to do so. It is difficult to judge how representative (or eccentric) such views are among the leaders of the UK's other "new universities" which, like UCE Birmingham were allowed by government legislation in 1992 to convert from their former status as polytechnics. While the idea that there is a self-referential aspect of "fame" and prestige status (so that is possible to be come famous for being famous) capture a descriptive feature of much that is observed in contemporary popular culture, the educational policy proposal that has been mounted on this foundation is nonetheless dismaying: "Let's give these top universities extra money to ensure they stay among the top universities in the world. Their success enhances the reputation of UK HE and allows the rest of us to cling to their academic coat-tails." If, as the writer asserted, the substance of what and how people at those "world-class universities" learn and teach is inconsequential for their fee-collecting power, and hence for their status, what is it that they need the extra money to do? Perhaps to provide students amenities that can induce the willingness of wealthy students to pay still higher fees? Prestigious private research universities in the U.S. have recently come in for quite severe criticisms on just those and associated faults in their approaches to the recruitment of applicants and the selection of undergraduates for admission. See, e.g., the publications reviewed in A. Delbanco, "Scandals of Higher Education," *New York Review of Books*, March 29, 2007: pp. 42-47.

higher education sector exceeds that in the US [see ANNEX p.1] by a substantial margin, the comparability of those figures is none too clear, and if were it accepted, it remains open to question whether overall resource inputs in the EU match those that are devoted to getting important findings, and getting them into print it the top English language scientific journals.

Fortunately, it is possible to consult a study carried out for the Office of Science and Technology in the UK Department of Trade and Industry by Gustavo Crespi and Aldo Geuna, that has considerably advanced the state of the art of measuring scientific "productivity" at the national level as a ratio of research output measures to research inputs, by allowing for the long research investment gestation lags, and publication lags between the inputs and the outputs.[33] The principal quantitative findings of this exercise are reproduced in the tables and notes of ANNEX (pp. 5, 6), two aspects of which bear particular notice here. Firstly, although there was found to be great stability over time in the rank-ordering of countries according to levels of productivity, when one examined the indexes themselves, it was clear that many of the European countries were catching up with the US and the UK. Second, Crespi and Geuna (2004) suggest that their results are consistent with the notion that part of this convergence process in regard to productivity-in-citations is being driven by the increasing tendency of scientists to publish in English when they had not done so previously, and this had been occurring particularly in the regions (including Europe) where the volume of publications haw grown faster than in the old "leaders" from the English –speaking world.

Of course, there are no simple answers to the question: "What is the role in the European innovation ecology of research universities, and of PROs more generally, and how well are they fulfilling it?" Their collective institutional mission may be expressed in terms of alternative extremes that range on one side from the improvement of economic performance and meeting the specific skill needs of society in the private sphere of business and the performance of public sector responsibilities. That frames the answer from the "investment viewpoint"; whereas at the alternative extreme, from the "consumption viewpoint", the universities are a principal agency for the civilizing of the society through the advancement of learning and the accumulation and transmission of shared knowledge, and by the inculcation habits of individual and collective learning that augment human capabilities. Is a relatively high national level of measured "scientific productivity" to be regarded as a "good thing" because it is likely to imply a commensurately high social marginal rate of return on public investments in R&D, which allow the release of the nation's resources for other high yield public (or private) purposes? Or does its virtue lie in the greater potential of the society to contribute to actual and symbolic cultural progress through the advancement of scientific understanding?[34]

[33] G. Crespi and A. Geuna, *TheProductivity of Science: An International Analysis*, Report for the Office of Science and Technology of the Department of Trade and Industry, SPRU-University of Sussex, 11 March 2004. Their approach is to estimate a dynamic production function-like relationship between current aggregate publication counts (weighted by journal impact factors) to the notional "stocks" of R&D capital formed by the past (distributed lag) flows of expenditures (HERD), allowing for a stock adjustment cost effects and control variables. An analogous model is developed for current flows of citations, as an alternative measure of the output of codified research findings. Further econometric sophistication in their approach involves the application of statistic optimization of the lag structures of these models.

[34] This obviously begs the question of whether the proxy measures of scientific output that were considered above are informative about either of the alternatively formulated roles of the research universities. The contrast between instrumental and intrinsic valuations in this context was neatly captured by the reply of an American theoretical physicist to a hostile member of the House of Representative who, in a public hearing ask the witness how his scientific work was contributing to the defence of Western Civilization: "Well Mr. Congressman, I thought that what we were doing was one of the things that made Western Civilization worth defending."

Needless to add there are many variant formulations, not least among which those stressing the significance of universities role in the generation of innovation, where higher education's and research training purpose is not to imparting rote knowledge but to develop and refine the capacity for independent creative thought and problem-solving. All of these variant views of what higher education systems are supposed to do can frame their role either more strongly in instrumental and materialist terms, or by giving primacy to the intrinsic the worth of the pursuit of further knowledge, and, of course, by seeking different points of balance between the two."

It is right that different universities evolve different missions with respect to the balance of education and research, with regard to the balance of curiosity and mission-oriented research and in relation to regional, national and international orientations. Specialization and excellence are the basis of a rich ecology from which innovation systems can be constructed. This does not mean that policy has no role to play given the underlying dynamic of development in function, organisation and funding methods. As long as Universities remain heavily dependent for funding, and in some countries for academic appointments, the Member States can exert great influence on the nature of the national knowledge ecologies. In particular, the proper funding of emerging areas of science through doctoral and post doctoral fellowships, research grants, research facilities and academic posts, can stimulate rapid growth of capability in a way that provides resources for innovation to firms exploiting these new areas. The creation of specialised research organisations bridging between industry and academia is also a task that governments are likely to fulfill more effectively. In so far as funds are provided to support the innovation efforts of firms these can be granted subject to collaboration so requiring the formation of an innovation system as a prerequisite of funding.

4. THE THRUST OF EU POLICIES AND PRACTICE: PROMOTING MORE DIRECT INVOLVMENT OF EUROPE'S UNIVERSITIES IN INNOVATION

It is hard to find a policy document from government, business or university sources that does not call for greater, wider or deeper "interactions" between private business firms and the universities and (PROs). This is no less true in the EU today than in any of the other OECD countries. **Research collaborations**, including joint-ventures is one form in which the public and quasi-public research institutions are enjoyed to make themselves for amenable and accommodating to private sector partners that seek to form cooperative projects. **Technology transfer** activities are seen as giving greater scope for university initiative to locate licensees for their IP, whereas a still more entrepreneurial the role is envisaged for **technology transfer offices** (TTOs), and technology licensing officers (TLOs) that assist in the formation of **university-based "start-ups" (**or "spin-off" firms) by arranging exclusive licensing agreements and helping faculty researchers to find sources of financing.

The EC Staff Working Paper [COM (2007 412/2:p. 52)] emphasizes this widely accepted view:

> From a societal perspective, more will be gained by letting our universities excel in knowledge creation while encouraging closer links with the rest of society, than by insisting that they should fund themselves mainly through commercializing their knowledge. The development of strong and sustained structured partnerships between universities and the surrounding society, including regional authorities, businesses and SMEs, has a direct impact on improving the economic performance of the whole region,

> through localized technological spill-overs, while at the same time being beneficial to universities….
>
> These partnerships include patenting, licensing, research collaborations with industry or the creation of innovative spin-offs. Without this market-driven interaction with R&D intensive companies, the impact of publicly funded university-based research on regional, national and European economies will inevitably be limited.

Regrettably, there is a lack of systematic data about what is happening recently across the EU in regard to university patenting, where it is taking place, how much is being invested in establishing TTO operations, how much patent licensing revenues are being generated and how these earning distributed among HEIs and PROs and the various provinces of the EU. This created an understandable inclination to rely on inferences from the apparent effectiveness of the "technology transfer" activities that had been stimulated by the introduction of the Bayh-Dole and Stevenson-Wydler legislation. Careful examination of the U.S. experience could be of substantial assistance in providing insights into some of the likely consequences of the promotion of academic patenting and licensing in the EU, even though various national "emulations" of the American institutional reform have not been strictly faithful to the original design, and the conditions into which they were introduced hardly replicated those of the U.S. prior to the 1980's.

For example, the extreme skew in the distribution of high value patents, and the dependence of the value of individual patents upon the portfolio of other related patents in which they are held, are quite generic features of the market for this form of intellectual property that help one to understand why only a handful among the 100 so research universities in the U.S. that absorbed for almost 90 percent of all federally funded HERD expenditures have been able to enjoyed appreciable income receipts from the patents filed on the publicly funded research findings of their faculties.[35] It would likewise tend to explain why something approach half of the universities that set up technology licensing offices reporting on their operations to the Association of Technology Managers (AUTM) failed to generate any licensing revenues from their patent holdings. But such information tended to be overlooked in the enthusiasm over the (quite illusory) prospects of being solve the funding problems of Europe's university systems by having many big institutional winners in the patent lottery.[36]

In many other regards, however, it is important to examine such information as is presently available about the actual European experience of university-business interactions that are being encouraged as means of promoting technological innovation, employment generating business formation and regional economic development.

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[35] The United States presently has an estimated 2,500 universities, of which 1,521 offer bachelors degrees in science and engineering (S&E), 826 offer Masters level degrees in S&E, and 345 offer Doctorate level degrees in S&E, according to the National Science Foundation, *Science and Engineering Indicators 2006*, NSF, Arlington VA, 2006: pp. 2-7, volume 1, and Table A2-1, volume 2.]

[36] On the evidence of the extreme degree of concentration in the distribution of university patent licenses, and especially of licensing revenues from patent holdings –both among and within U.S. universities—see, e.g., See AUTM, *Licensing Survey: FY 2002*, Norwalk, CT: Association of University Technology Managers, Inc., 2003; and discussion in D. C. Mowery et al., *Ivory Tower and Corporate Lab* (2004). The AUTM survey of universities and public research organisations in the U.S. for 2004 obtained results on outcomes for between 190 and 200 universities, or a minimum of 13% of American B.A. degree-granting institutions, and included 96 of the 100 HEI's that accounted for 87 percent of federal grants and contracts for university-based R&D performance.

4.1 TECHNOLOGY LICENSING AS A MODUS OF TECHNOLOGY TRANSFER TO INDUSTRY

The international movement to emulate the U.S. institutional reforms of the early 1980's that gave universities and publicly funded technology research organizations the right (rather than a privilege granted by a sponsoring agency) to own and derive income from the commercialization of IP based on their researchers' inventions, has developed remarkable momentum since its inception at the end of the 1990s [see e.g., Mowery and Sampat (2005)]. The process of change and adaptation that was thereby set in motion among the EU member states has not yielded the dramatic effects upon innovation and employment growth in Europe that had been promised by who enthusiastically prescribed a dose of "the Bayh-Dole solution" for the region's sluggish economies.

But such expectations were at best unrealistic, and in too many instances stemmed from contemporary European observers mistaken suppositions regarding the sources of the revival of productivity growth and the "information technology" investment boom in the American economy during the late 1990's; and more widely shared misapprehensions regarding the fundamental factors that were responsible for the rising frequency with which patents applications filed at the USPTO during the 1980's and 1990's were citing scientific papers academic authors.[37]

The movement to promote "technology transfers" from universities to industry through the medium of patent licensing was fueled by a widespread supposition that European academic research was dangerously disconnected from the processes of private sector innovation. This belief rested largely on the observation at the turn of the century that the regions' universities were not extensively involved as corporate entities in filing applications for patents, and negotiating the terms on which the inventions could be commercially exploited (whether by being "worked" or not) business licensees. The obvious contrast was that drawn with contemporary scene in the U.S. during the frenzied era of the dot-com and biogenetics boom, where research universities' patenting and the licensing of technology to venture-capital fueled "start-ups" was rapidly growing. What the accuracy of European perceptions about the realities of events taking place on the far side of the Atlantic ocean, it has become clear that there was a serious misconception of the realities of university-industry technology transfers closer to home. Several of recent studies have revealed, however belatedly that much of the university research leading to patents in Europe does not show up readily in the statistics, because private firms rather than the universities themselves apply for the patent.[38]

[37] It is unnecessary to review the details of these misunderstandings, which are discussed in P. A. David, "Innovation and Europe's academic institutions -- second thoughts about embracing the Bayh-Dole regime," in *Perspectives on Innovation*, F. Malerba and S. Brusoni, eds. Cambridge: Cambridge University Press, 2007. [Available as SIEPR Policy Paper 04-027, May 2005) [Available at: http://siepr.stanford.edu/papers/pdf/04-27.html.] For a comparison of the questionable effects of Bayh-Dole on the licensing activities of three major USA universities see Mowery *et al.,* 2004.

[38] M. Balconi, S. Breschi, and F. Lissoni, "Networks of inventors and the role of academia: An exploration of Italian patent data," *Research Policy*, 33(1), 2004: pp.127-45; A. Geuna and L. Nesta, "University patenting and its effects on academic research: The emerging European evidence," *Research Policy*, 35 (June-July), 2006 [Special Issue on Property and the Pursuit Issues Affecting Scientific Research, eds., P. A. David and B. H. Hall]; G. A. Crespi, A. Geuna, and B.Verspagen, "University IPRs and Knowledge Transfer. Is the IPR ownership model more efficient?" Presented to the 6th Annual Roundtable of Engineering Research, Georgia Tech College of Management, 1-3 December 2006 [available at: http://mgt.gatech.edu/news_room/news/2006/reer/files/reer_university_iprs.pdf]. of Knowledge: IPR

The impression that university professors in the physical sciences and engineering were not engaged in patent-worthy inventive activities whose results were of interest to industrial firms was firmly dispelled for the case of Italy by a study of the identities of inventors named in patents issued by the European Patent office during 1978-99: Balconi et al (2004: Table 3) found that for many research area the Italian academic *inventors* of those patents formed quite a sizeable share of all the professors working in those fields on the faculties of Italy's universities and polytechnics at the close of that period.[39] In 11 of the 20 research fields studied, 13.9 percent or more of the professors working in the field were identified as the inventor of EPO patents issued for in the corresponding field; in the case of quite a few specialty areas such as mechanical and chemical bioengineering, and industrial and materials chemistry, the corresponding proportions were much higher – ranging from one-third to one-half. The transfer of the ownership of those patents to industrial firms was the norm in Italy, as was the case elsewhere in western Europe during this era.[40] According to Crespi, Geuna and Verspargen (2006), about 80 percent of the EPO patents with at least one academic inventor are not owned by the university, which means that no statistical indication a university involvement in the technology's creation would be found by studying the patent office records.

Thus, the appearance of a lack of "university patents" in Europe must be understood to be a lack of *university-owned* patents, and not necessarily indicative of any dearth of *university-invented* patents. Once the data are corrected to take into account of the different ownership structure in Europe and the U.S., very simple calculations made by Crespi, Geuna and Verspagen (2006) indicate the European academic system seems to perform considerably better than was formerly believed to be the case: indeed, the patenting output of European universities' has lags behind only one among the US universities – and in that exception the difference was quite marginal.

If there are grounds for suspecting that it may not really have been necessary for Europe to embrace the Bayh-Dole regime's approach to effecting "technology transfers" from academic labs to industrial firms, there also are doubts as to whether the likelihood of innovative success ensuing from such transactions is raised by having university's rather than firms own the patents on academic inventions. There are theoretical arguments about this, pro and con, because the arguments turn essential upon on the comparative strength of opposing effects: are firms likely to make a better job of the innovation process because they have greater control over the development of their own inventions?, or is it less likely that viable academic inventions will be shelved if the inventor's institution retains control of the patent and has incentives to find a way of licensing it to a company that will generate royalty earnings by direct exploitation? Since the matter is therefore an empirical question, it is fortunate that Crespi, Geuna and Verspargen recently have carried out a statistical analysis of the effects of university ownership on the rate of commercial application (diffusion) of a patent, and on the commercial value of a patent, based

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[39] The statistics presented by Balconi et al (2004) in Table 3 refer to 20 specific science and engineering research fields in which at least 20 academic inventors (of all nationalities) could be observed in the EPO patent data for the years 1978-1999. The proportions referred in the following text pertain to Italian academic inventors as a fraction of total faculty enrolments in the corresponding fields at Italian universities and polytechnics on 31 October 2000.

[40] Paradoxically, this was the practice despite the fact that in that at that time Italian universities had titular rights to own the patents filed by their employees, which was anomalous in the context of the German, Dutch and other national universities at the time; the practice in Italian, removed the anomaly by permitted their professors to assign the rights directly to industrial companies – a practice that subsequently was ratified by a change in the Italian law. While that change seemed, quixotically to run against the stream of Bayh-Dole inspired "reforms" that were underway in other nation's university systems at the time, giving patent rights formerly held as the professors' prerogatives, to their employers. Operationally, however, the Italian reform was more in accord with the intention of facilitating the transfer of new technologies to industry, legalizing the way it had previously been done.

upon the experience of European academic inventions for which patents were issued by the EPO.[41] Their analysis controls for the different (ex ante observed) characteristics of university owned and non-university owned patents, and hence is in accordance with the theory that suggests that university ownership is the endogenous outcome of a bargaining game. Both before and after controlling for such differences between patents, they find no statistically significant effects of university ownership of patents. The only significant (positive) effect reported is that university-owned patents are more often licensed out, but this does not lead to an overall increase in the rate of commercial use. Hence the authors conclude that they can find no evidence of "market failure" that would call for additional legislation in order to make university patenting more attractive in Europe. Their suggestion that whether or not universities own commercially interesting patents resulting from their research appears not to matter, being adjusted in the terms of the inter-organizational bargaining process, is an interpretation of the findings that should gratify admirers of the Coase Theorem's assertion that the locus of ownership of valuable property does not carry efficiency implications where transactions costs are not very high.

Nonetheless, even though impelled by misconceptions of the realities both in the U.S. and in Europe, there is now a general sense that the shock to the administrative system into which Europe's universities had settled in the era following the rapid post-World War II proliferation of new institutional foundations, has been on balance salutary in its effects for the longer term. Perhaps that is so. It has encouraged fresh thinking about the potential payoffs of publicly funded research in terms of commercial innovation in small and medium size industries, and of the support that applied research in areas where new science might spawn new technologies of interest to major new industries. It has precipitated and legitimized the assertion of university rights to ownership of intellectual property vis-à-vis the claims of their employees –an alteration in institutional norms that had occurred almost universally in the U.S. before the 1970s. More significantly, perhaps, it had the effect of encouraging a general re-examination of university regulations affecting the activities of academic researchers in Europe. The liberalization -- for the benefit of universities -- of many rules that had been imposed uniformly on state institutions and their employees, in turn, has opened the way to a broader consideration of the need for greater institutional independence and autonomy, and brought more realistic attention to the creation of incentive mechanisms that would redirect individual activities and raise productivity among those who worked within these organizations.[42]

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[41] G. A. Crespi, A. Geuna, and B.Verspagen, "University IPRs and Knowledge Transfer. Is the IPR ownership model more efficient?" Presented to the 6th Annual Roundtable of Engineering Research, Georgia Tech College of Management, 1-3 December 2006. [Available at: http://mgt.gatech.edu/news_room/news/2006/reer/files/reer_university_iprs.pdf.]

[42] In this regard it is significant that the latter considerations led the Italian government to award ownership rights in patents to their faculty employees, whereas the industrial treatment of "work for hire" by employed inventors was applied to university faculty by all the other European states. Thus, in Denmark, public research organizations including universities were given the rights to all inventions funded by the Ministry of Research and Technology (in 1999); French legislation authorized the creation of TTO's at universities (in 1999), and university and PRO assertion of rights to employee inventions was "recommended" by the Ministry of Research (in 2001); the "professor's privilege" was removed in Germany by the Ministry of Science and Education (in 2002); in Austria, Ireland, Spain, and other European countries the employment laws have been altered to removed "professor's exemption" from the assignment to employers of the IP rights to the inventions of their employees. See OECD, Turning Science into Business: Patenting and Licensing at Public Research Organizations, Paris: OECD; D. C. Mowery and B. N. Sampat, " Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Model for Other OECD Governments?" *Journ. Technology Transfer*, 20(1-2), 2005: pp. 1115-127.

These have been important steps toward the flexibility needed for R&D collaborations throughout the ERA, even though a considerable distance remains to be traveled by the respective national government authorities along the path towards granting greater autonomy for to their institutions; and also by consortia and regional coalitions of the institutions themselves to remove the impediments to collaboration and inter-university mobility of personnel that continues to fragment the European market for academic science and engineering researchers. Furthermore, although European governments have not hesitated to urge business corporations to accept the necessity of investments in "organizational re-engineering" to take full advantage of new technologies and consequent new ways of working, they have not been so quick to put this good advice into practice "closer to home" -- when urging "modernization" upon their respective educational and research institutions. Yet it is now more widely recognized that the "modernizing" of university governance and management is not a costless process, and like "business re-engineering" requires up-front incremental expenditures to effect the transformations that are expected to yield sustainable future gains in the efficiency of resource use.

4.2 TECHNOLOGY TRANSFER OFFICES AND THEIR PERFORMANCE IN EUROPE

Corporate research managers in the U.S. lately have begun to complain publicly of the rise of "academic greed" and to express their frustration with having to deal with universities who appear to them as "rentier IP-owners" demanding cash for licensing rights -- not so very different, then, from the "patent trolls" that "prey upon" producers of goods embodying innovative technologies! They point to their unaccustomed difficulties in negotiating IP licensing terms where there was so little scope for cross-licensing and other side-arrangements (or, indeed, for threats of retaliatory business competition). They are unsparing and sound rather ungenerous in denigrating what they characterize as the lack of expertise, experience and professional competence on the part of many of the U.S. university technology licensing offices with whom they have dealt..

Behind these possibly self-serving business complaints, however, there are sources of real problems in the management of TTO's that deserve closer examination, for some of them are structural in origins and should not be dismissed casually as "start-up" problems in new organizations that will soon be remedied through learning-by-doing. To be sure, there are some highly expert technology transfer organizations in place already at European universities and technology research organizations, and greater number of very effective technology licensing offices are to be found among the nonetheless restricted set of American universities that have scored the bulk of the major patent licensing "hits." But the acquisition of expertise is in good part a function of experience and opportunity, and, as has been pointed out, the opportunities for learning in this case are almost as unevenly distributed as are the licensing revenues that eventual flow to the universities.

A self-reinforcing feedback dynamic is at work here, as well: a TTO that has scant licensing revenue or other income (perhaps from equity in start-ups) to its credit with the university administration will be hard put to offer the sort of compensation packages that would enable them to recruit top-flight managers. After all, they will be competing against R&D-intensive corporations for talent of the very kind that they find seated opposite them at the negotiation table. Perhaps even more than is the case in the U.S., a symptom of the deeper performance problems of TTO's at Europe's universities is that typical staffing levels are far too high for the volume of transactions that they effect. There are no comprehensive figures available for the EU region but the 2004 ProTon survey of TTOs conducted for the EU reported that there were approximately 1000 such services. Survey responses from obtained from the latter reveal performance profiles that are quite different from those reported by the 2006 survey of members of the Association of European Science and Technology Transfer Professional (ASTP) carried out by Antony Arundel and Catalina Bordoy at MERIT.[43] Whereas ProTon found that most of the offices have between 5 and 10 full-time staff and generated 3 licensing deals and 3 "spin-offs" per year, the median staffing level of the ASTP respondents falls in the 5-7 range, since there are c. 47 offices out of 101 in the range immediately below that, and the typical TTO concluded 18 licenses per year and generated an average of 2.6 start-ups.

The differences between the two sets of survey findings are too striking to be attributable to any temporal changes, as the ASTP study collected data for 2004 and 2005: compared with the ProTon survey of TTO 's in 2004, commissioned by the EC totals, the average TTO in the ASTP survey for 2006 reported generally higher activity levels in the area of patenting and licensing: 36% more invention disclosures , 56% more patent applications, 115% more license options, and 7.8 times more licensing revenues, whereas the ProTon respondents reported 5% more start-up establishments than the ASTP respondents. Arundel and Bordoy (2006) suggest that most of the difference in the ProTon and ASTP surveys is due to the heavy weight of Spain and Italy among the former responses, as those countries contributed 57 percent of the 172 ProTon responses, compared to only 3 percent of the 101 usable ASTP responses, which were drawn almost exclusively from countries in northern Europe and included more TTO's than appeared in the ProTon survey from each of the following: UK, Belgium, Ireland, Denmark, Finland, Sweden, Greece, Hungary, Switzerland and the Netherlands.

This intra-European difference is noteworthy because it would appear to account for one source of the contrasts that are observed between EU TTOs' performance and that of their U.S. counterparts: A comparison of U.S. AUTM affiliated institutions performance with that of all 101 of the ASTP survey respondents combined (provided by Arundel and Bordoy, 2006:Table 5.1) shows that the Americans out-performed the European ASTP institutions on invention disclosures, patent applications and patent grants per million of research expenditures. Conversely, the average performance of all European ASTP members is better for licenses executed and the number of established start-ups. These results indicate that the AUTM institutions are substantially more successful in patenting, particularly in filing patent applications – which may well reflect the comparative simplicity and lower costs in the U.S., whereas the ASTP members are more successful at establishing start-ups.

Those contrasts, however, should not automatically be ascribed to systematic differences in the capabilities of the typical TTOs in the two regions, and may well reflect differences in the economic environments in which they are operating. The intra-EU differences disclosed by comparing the composition of the ProTon and ASTP responses suggests that where a region's industrial structure is stronger in R&D-intensive manufacturing activities, there is likely to be a greater demand for patent licensing from universities; whereas in less industrially advanced regions local government authorities are likely to be encouraging the development of clusters of small and medium scale enterprise, and its universities TTO's tend to devote a great part of their efforts to "start-ups" – which are on average is a more costly, personnel-intensive undertakings. Then too, there may be a more ample annual flow of "invention disclosures" from universities research groups that have a longer period of interaction with their institution's technology licensing office, and are (in at least some instances) under obligation to disclose potentially patentable discoveries and inventions.

Unfortunately, the dimension of TTO performance about which there is virtually no systematic data for Europe is success rates in licensing patents at fees that at least cover the sunk costs of the patent development and application process, or in identifying and launching "start-ups" that survive to

[43] A. Arundel and C. Bordoy, *The 2006 ASTP Survey: Final Report*. Maastricht, NL: MERIT [available at: http://www.merit.unu.edu/publications/docs/200605_ASTP.pdf. Comparative data for the ASTP and ProTon Surveys is provided in the Annex to the former.

become growing, commercially profitable enterprises. There too, of course, what can be said on the basis of empirical information about the experience of university spin-offs points to the role of many other features of the ecology that shape the generation of economically successful technologically based innovations.

4.3 UNIVERSITY "START-UPS," VENTURES IN VENTURE CAPITAL FUNDING, AND PROMOTION OF REGIONAL DEVELOPMENT "CLUSTERS"

Start-ups and spin-offs figure prominently among the forms of "university-business interaction" that governments seeking to stimulate technological innovation discuss. More than the passive licensing of university-owned intellectual property to interested firms, this is a more active mode of "technology transfer" from the academic to the commercial sphere. Despite the difficulties and inherent uncertainties surround the launching and successful management of a viable new business based upon a technological innovation, the commitment of resources to fostering start-ups and spin-offs has attracted the enthusiastic attention of promoters of "the entrepreneurial university ethos." Institutional support for the formation of connections between academic inventors and venture capitalists, including the exchange of exclusive patent licenses for equity stakes in new business firms, also continues to be seen as a favored "third stream" activity by means of which publicly funded research universities can contribute to national, regional and local economic development.

Beginning with American Research and Development (ARD), the first modern venture capital firm, started early in the post WW II era by a Boston area group that included MIT President Karl Compton, Harvard Business School Professor Georges Doriot, and local business leaders, venture capitalists have gone on looking to university research as a source of new technologies that could be profitably commercialized. In the pioneering instance just cited, the attraction was the military technologies –many derived from microwave and solid state physics devices developed by MIT labs during the Second World War. Many of the most successful enterprises that had been backed by VC funding later in the century -- such as Genentech, Netscape Communications and Cisco Systems – similarly were "spin-outs" from frontier fields of university-research.

Recollection of those salient successes among the clusters of new, small firms that commercialize novel technologies has contributed to the attractiveness of policies promoting start-ups based on university originated inventions. Typically, "academic start-ups" and "spin-offs" are seen by university administrators and regional development authorities as sources of multiple benefits: generators of revenue for the institution, sources of employment generation and income for the surrounding community, and possibly of local property value appreciation and tax collection), supplemental opportunities for personal economic gain and career success that enhance the institution's ability to attract faculty in the fields of science and engineering –and thereby augment its ability to compete for public (and private) research grants and contracts in those areas.

As attractive as such prospects have been, the record of university management of start-ups is considerably more "mixed," and points to difficulties (if not outright "disasters") that may await such enterprises. In the lat 1970's enthusiasm for biotech start-ups, university officials and trustees of Boston University sank more that $90 million, more than two-thirds of the institution's entire endowment, in a privately held biotechnology start-up company, Seragen, founded by a number of BU faculty scientists. Much of this investment was committed after the initial venture capital backers had decided to liquidate their stake in the business, which was viewed as an opportunity—rather than a warning.. Although Seragen eventually contemplated its IPO, sale revenues from its promised products proved to be a more elusive goal. By 1997, the value of the University's equity stake had dwindled to $4 million.[44]

Successfully managing the commercial opportunity presented to it by the Internet revolution provided no less of a challenge for the University of Illinois.[45] Having developed the Mosaic browser (through the research of Marc Andreesen at the NSF-sponsored National Center for Supercomputing Applications on its Urbana-Champaign campus) in 1993, the University licensed the technology to Spyglass Technologies, a Boston-based start-up. It soon became embroiled in a bitter dispute with former university employees, against whom it initiated litigation when they launched a separate company to commercialize a related technology. When offered a large block of stock in the new firm in settlement of the dispute, the university administration rejected it, and insisted on a (rather modest) cash payment. That was a management error, to which the acrimony of the preceding dispute may have contributed. As things turned out, Spyglass Technologies had abandoned development work on its Internet browser by 2000, and the value of the equity that had been proffered by the new company, Netscape Communications, would have been hundreds of time greater than the modest cash settlement that the University had managed to extract from it back 1995.

These are is not the only prominent – yet infrequently mentioned – instances of such failures. Lerner's (2005) review of the record of U.S. university "start-ups" shows that managing new technologically-based ventures is hard. Indeed, hard enough to render this a high-risk and high-yield field of investment, even when the enterprise is not being built around discoveries or inventions over whose commercial exploitation academic scientists and university administrators with little if any business management and financial experience (and other quite complicated career goals), are in a position to assert a significant degree of control. As one experienced inventor-industrialist remarked, in relating his frustrating experiences as a venture capitalist focusing on start-ups from a leading West Coast university: "The trouble with engineering professors and deans these days that what they want is a ten million dollar start-up on their CV, not to have created a business with serious long-term growth potential."

The more general managerial problems are those likely to be encountered in the transactions between knowledgeable scientists and engineers, on the one hand, and, on the other side, cautious professional business managers and outside investors who cannot afford reckless risk-taking. The asymmetric distribution of information about highly technical matters that may affect R&D costs, product attributes, and marketing requirements leads investors to want the scientists to carry enough of the risks to elicit full disclosure of information that is pertinent to the contemplated business; but strategic withholding of knowledge is only one source of difficulty, when the connections and implications of the technical knowledge are not fully appreciated by academics seeking financing for their partially developed and incompletely articulated technological innovations.

Most university start-ups yield only modest returns for their institution, rather than enormous wealth. While universities can add considerable value to new firms if it has experienced

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[44] This story is related in J. Lerner, "The university and the start-up: lessons from the past two decades," *Journ.Technology Transfer*, 20(1.2), 2005: pp.49-56 .

[45] See G. Blumenstyk, "Accord in the Mosaic War: U. of Illinois and Private Company Agree on Product for Navigating the Internet," *Chronicle of Higher Education,* 41. 6 January 1995; Lerner (2005: p.50) provides a brief account.

personnel that can act as intermediaries in screening invention disclosures, and guide promising prospects to expert intellectual property attorneys and contacts with knowledgeable and experienced entrepreneurs and financiers. Trying to internalize that process within a university technology transfer office is a costly undertaking if it is to be done well, and, moreover an activity that generally will call for "start-up" funding from an institution that is seeking incremental revenues and therefore is likely to be impatient with an extended learning process unless it sees the whole effort as essentially a required symbolic expenditure.

The conditions that underlying this state of affairs are the same as those which lead to the conclusion that university financing of start-ups through and *internal* venture capital fund generally will not be a successful strategy for the institution. The difficulties that have been encountered by most institutions that adopt the internal venture fund approach stem from an unwillingness to provide sufficiently powerful managerial incentives to attract top-flight personnel; corporate venture capital funds are similarly reluctant to compensate venture-managers through so-call "carried interest" (profit-sharing) provisions, fearing that in the few instances of big investment payoffs they would have to make enormous payments on those contracts. Since successful risk-taking is under rewarded, and failures tend to be excessive punished, corporate venture-managers tend to adopt conservative approaches to investing, and while there still is only quite limited data available about the university venture funds there is little prospect that they will turn out to behave very differently.[46]

Moreover, there are considerable costs in terms of academic administrators' attention to the heightened potentials for conflict-of-interest that are present when their institution participates directly (and even indirectly) as equity-holders who are asked to respond to the special business needs of the young companies launched by members of their faculty. Institutional regulations that seek to simplify the task of close monitoring in order to avert serious conflicts-of-interest, in many instances prohibit faculty researcher's involvement with start-up firms altogether; or they may permit consulting but forbid equity-ownership in such ventures. This course is likely to severely restrict the ability of researchers with highly relevant scientific expertise to involve themselves in new enterprises, especially where outside venture capitalists have insisted that the company's executives and non-executive directors hold significant equity positions in the business.

University-owned venture capital funds may seem attractive in that they may induce greater administrative flexibility, for example, in setting regulations that are more accommodating to the needs of nascent firms, while mitigating the risks perceived conflicts-of-interest by establishing an independent managerial structure that puts some distance between the university administrators and the personnel that are work closely with the young start-up firms. The distance can be further increased if the fund diversifies its investment portfolio by funding the start-ups of other institutions, but, obviously that would work against the purpose of enhancing the revenues derived from the university's own intellectual property and (faculty) "knowledge assets." Further, to induce highly able independent managers to take risks with investments in start-up is much the same proposition as that facing private

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[46] See Atkinson (2003); Lerner (2005):p.53. S. H. Atkinson, "University-affiliated venture capital funds," *Health Affairs*, 13, 2003: pp. 159-175.

universities that need first-rate financial expertise in managing their endowment portfolios. It is an expensive proposition that is likely to elicit complaints from faculty (and alumni).

An additional set of consideration that may contribute to the modest returns yielded by university programs aiming to commercialize publicly funded research findings is that their very success makes them vulnerable targets for complaints from business rivals of the new enterprise that has received exclusive or preferential licenses to exploit the new technology. Licensing university owned patents to foreign start-ups, or established corporations is a particular invitation to mire the administration in domestic political troubles, especially when the inventions in question arose from research that was government supported, or benefited from grants awarded by tax-exempt private foundations and charities. Little if any immunity from adverse public relations on this score is likely to be conferred upon the university that waits for an extended period while search for a national company that would license the technology, or grants exclusive commercialization rights to a domestic corporation that subsequently discloses its intention to outsource production of the new products to overseas suppliers. Universities as public or quasi-public entities are expected both to seek financial returns while acting with "due diligence" on behalf of the interests of the tax-paying public – however those may be construed at the moment by the latter's political representatives. As the recent EC Staff Working Document associated with the ERA Green Paper has noted (COM 2007, 161: p. 63) in Europe "the question of whether "European" public research results should be primarily exploited in Europe still remains open."

4.4 SOCIAL INTERACTIONS AND THE FACILITATION OF COLLABORATION

Beyond the overtly commercial and explicitly contractual interactions involving IP, whose role at the macro-system level in supporting R&D investment and innovation tends to be accorded prime place in general policy prescriptions, the importance of other channels of "interaction" with business is often stressed in discussions of what the leadership of Europe's universities should be doing in that regard. Prominent on this list are the variety of interpersonal and inter-organizational connections that bring participants in academic research into regular contact with members of the local, regional and national business communities. Under the heading "The role of the universities in promoting business-university collaboration," the *Lambert Review* (2003: p. 41), for example, remarked on the growing role that universities (in the U.K.) have taken in their cities and regions during recent decades:

> "Vice-chancellors often have links with the CEOs of major local companies, with chambers of commerce, with their development agency and with NHS Trusts and other community service providers in their region. Academics work with individual businesses through consultancy, contract or collaborative research services. University careers services co-operate with the businesses which wish to recruit their graduates or provide work placements for their students."

The trend toward organized institutional involvement – as distinct from personal connections between university professors and industrial and financial firms in their local -- is indeed an ongoing process for many of Europe's HEI's. But, the reader of the *Lambert Review* who was familiar with the U.S. university scene, especially that among the public (Land Grant) institutions, would be struck by its suggestion of novelty in top level administrators having links with CEOs and local business leaders, inasmuch as this would be presumed to be the case for their American counterparts.

Also noteworthy, as a reflection of the "top down" impetus for the establishment of such relationships, is the quoted passage's emphasis on the co-operation of university careers services with recruiters from business firms. At most major U.S. research universities – where the organized placement services of the professional schools, as well as those of the undergraduate colleges have long been established -- the important recruiting contacts with graduate scientists and engineers typically arranged at the level of the individual departments, and often are linked with a variety of "industrial affiliates" programs. This is important in view of the expert screening functions that are performed for potential employers by universities' graduate educational programs and faculty supervisors. That publicly subsidized service (provided as it is without fee) is especially valuable for companies seeking promising fresh talent training in frontier fields of science and engineering, where the firms themselves may lack the expertise, as well as the extended opportunity to observe and assess the abilities of current graduates and form contacts with those who will be seeking employment positions in the near future.[47] The formation of enduring ties for the transfer of knowledge through the movement of personnel gives business organizations access to the craft aspects of applying new techniques, contacts with new recruits' personal network of other young researchers, and an advantage in spotting exceptional capabilities to conduct high caliber research. Such ties are sustained by personal relationships with the student's professors, and strengthened by "repeat play" which tend to inhibit the latter's inclination to "over-sell" members of their current crop of Ph.D.'s and postdocs; similarly, the prospects of having to try to recruit next year from the same source works to induce the firms to be more candid in describing the nature of the employment opportunities that professors may recommend to their good students. The point here is that the direct participation of the parties, rather than institutionally provided third-party intermediation services, will generally be a requirement for successful "relationship management" in the market for young research talent.

Perhaps the greater prevalence of such arrangements that can be observed in science and engineering departments and research groups at U.S. universities can be attributed to the greater degree of autonomy that university administrations there have allowed to these units, permitting (and indeed providing them with initial help) them to create special programs of lectures, seminars, and gatherings of "industry associates" by soliciting and using funds contributed by the business invitees who participate as sponsors of those events. Initiatives of this kind, it must be said, are also an aspect of the traditions of local community and regional involvement that were developed in the agricultural and engineering schools of State (public land grant) universities in America. This form of direct engagement with the society beyond the precincts of the academy has been further reinforced and extended to the private HEI's in the U.S. by the generally more intense competition among them in the placement of graduating students in national and regional job markets – which is especially pronounced in the cases of the professional schools and graduate science and engineering faculties. Whatever the precise sources of these contrasts may be, the obvious suggestion to be registered here is that interesting interactions and productive engagements of this kind arise under conditions that have allowed greater scope for initiative, and attached rewards to actions taken not by Vice Chancellors, but at the levels within these institutions where one is most likely to find the specific information and technical judgments about the subjects of

[47] The value of the screening function for employers is the other side of the coin of the "signalling" benefits that are obtained by young researcher who trained and choose to continue in post doctoral research positions in academic departments and labs where publication policies conform to open science norms of rapid and complete disclosure. On job market signalling and screening externalities in this context see, e.g., Dasgupta and David (1994), sect.7.1, pp. 511-513.

mutual interest to academic researchers and knowledge-seeking corporate personnel. It implies also that when they work successfully, they do so within an ecological that provides a web of supporting connections and mutually reinforcing incentives which need to be studied and understood before attempting to transplant and adapt this important mechanism for "connectivity" in new institutional and cultural settings.[48]

It is only reasonable that considerable effort will be entailed in order to properly align mutual expectations among the parties to a collaboration when they approach the negotiating table with quite different, and conflicting goals that have been organizationally mandated. Nevertheless, the extent to which that investment is undertaken by both sides does appear to strongly shape whether, and how well business-university research collaborations turn out to benefit both parties, and whether they are able to evolve into more enduring "connected" relationships. When one starts the alignment process at the upper echelons of the administrative hierarchies of organizations that are a differentiated in their purposes and concerns as business companies and universities, the conflicts are likely to appear most salient and the prospective negotiation process more difficult and protracted, and uncertain in their outcome; whereas, the existence or absence of common interests and appreciation of the magnitude and division of prospective gains from cooperation usually will be quite readily established. The question then is whether the benefits in terms of the enhanced capacity to carry out the projected line of research are deemed sufficiently important to their respective (academic and business) organizations that mutual accommodations will be reached to "make it happen."

The organizational structure of most research universities, in which the upper levels of administration typically have at best only a derived interest in pursuing the particular substantive research programs that animate members of their research faculty, and are likely to eschew any attempt to evaluate and prioritize among them on the basis of their comparative scientific interest or societal worth. Accordingly, university administrators rarely if ever approach firms with proposals to engage in particular research projects that would involve collaborations between specified groups or individual faculty scientists and engineers and counterparts who are employed in the business R&D labs. Instead, the research director of a company that has decided that sponsoring a collaborative project with certain university-based research scientists would be beneficial to her organization's "bottom line," usually will have authority to take the initiative of approaching the prospective academic partners to discuss such an arrangement. But, as the latter, in their capacities of research faculty members rather than officers of the university usually do not have corresponding authority to negotiate formal inter-organizational agreements, and the business firm's representatives find themselves told they must deal with the university administration, and more precisely with one or a number of "service units" within the institution (variously described as the office of external relations," "sponsored research office," "university research services," "technology

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[48] This caution might be subsumed as part of the general warning against the "mix-and-match" approach to institutional reform and problem selection in science and policy-making, a tendency that is encouraged by international comparative studies that seek to identify "best practices." As has been pointed out by more than one observer of this fashionable practices (but see, e.g., P. A. David and D. Foray, "Accessing and Expanding the Science and Technology Knowledge Base", *STI Review: O.E.C.D. Science, Technology, Industry,* No.16, Fall, 1995) .Examining particular institutions, organizational forms, regulatory structures, or cultural practices in isolation from the ecologies in which they are likely to evolved, and searching for correlations between desired system level outcomes with their presence in the country or regional cross-section data, has been fashionable but as a rule offers little if any guidance about how to move from one functional configuration to another that will be not only viable but more effective.

transfer office," all of whom will in one way or another be equipped with legal counsel and contract negotiators.

Reasonable as this may appear as a procedure reflecting the different specializations of the people whose expertise the university calls upon, problems with its operation in practice often arise precisely because the primary concerns of these specialized services typically have little to do with the specifics of the professors' interests in the research collaboration.[49] Rather, their professional purpose is to secure such financial benefits that can be extracted by "the university" (directly or indirectly) in exchange for agreeing that its facilities and faculty resources will be permitted perform their part of the contemplated collaborative work, and that the university will bear responsibility should they refuse to perform in accordance with the terms of the contract. Their competence and role also requires their performance of "due diligence" -- by trying to identify all the conceivable risks and costs that could stem from their institution's exposure to legal liabilities and adverse publicity occasioned by participating in the proposed collaboration.

The uncertainties about the nature of the products and processes of research, conjoined with the professional incentives of those charged with performing "due diligence" – and their inability to calculate the countervailing value of the losses entail in not doing the research, tend to promote behaviors that reflect extreme risk aversion. In other words, these agents of the university are pre-disposed to advocate and adopt a tough bargaining stance, trying to get the other collaborating party (or parties) to bear the liabilities, or the costs of insuring against them; and when that appears to be infeasible, they are not hesitant to counsel against that the project not be undertaken by their institution.[50] What happens in such cases appear to depend upon whether or not the faculty researchers who are keen to do the science are able to persuade people at some higher levels in the university administration that it would not be in the institution's long-term interest to refuse to allow his or her research groups to seize the opportunity of a collaboration with the firm in question. When the individuals in question are valued by their university administration, whether for their academic prestige or for their ability to recruit talented young faculty, or for their track record of success in securing large public research grants and the overhead support that these bring, their persuasive efforts to find a compromise arrangement in which the university does not try to extract the maximum concessions from the firm, or bears more of the risk than its lawyers think is prudent, are likely to be successful. This is especially likely if there is a credible threat that the professor

[49] The difficulties occasioned by this internal organizational structure of universities, which contributes to separating the interest of the institution as a "research host" from that of its faculty researchers, thereby placing these research "service units" in a regulatory role vis-à-vis the latter, are considerable. But they are far from arbitrary or capricious, in view of the potential legal complexities that contractual agreements for collaborative research performance may entail. For further discussion see P. A. David and M. Spence, "Towards Institutional Infrastructures for e-Science: The Scope of the Challenges," [A Report to the Joint Information Systems Committee of the Research Councils of Great Britain], *Oxford Internet Institute Report No. 2*. September 2003, [Available at: http://www.oii.ox.ac.uk/resources/publications/OIIRR_E-Science_0903.pdf.]

[50] That this can be an unwelcome surprise to corporate representatives who were under the impression that "the university" would be symmetrically responding to the interest of the faculty counterparts of their own research group, is perhaps responsible for the shocked and disparaging terms in which research directors of large, R&D-intensive U.S. companies relate their experiences in negotiations with universities over the IP rights to joint R&D ventures. See the 2003 survey results reported by H.R. Hertzfeld, A.N. Link, and N.S. Vonortas, "Intellectual Property Protection Mechanisms in Research Partnerships," *Research Policy*, 35 (June-July), 2006 [Special Issue on Property and the Pursuit of Knowledge: IPR Issues Affecting Scientific Research, eds., P. A. David and B. H. Hall], and commentary on this material (as summarized by Table 1) in P.A. David,

will go to another research institution –where, as the formulaic expression puts its in such conversations, he or she "will feel really wanted."

The point of entering into these seemingly sordid details is to bring into the light the way that complex innovation systems emerge. In the case at hand it will be seen that more active competition among research institutions for productive scientists -- especially where it receives additional impetus from the usefulness of their talents in their university's competition for public research funding, will have the indirect effect of working as a countervailing force against the internal organizational impediments to the formation of "connectivity" between academic and business researchers. Regulatory structures that permit universities to compete to attract and retain research faculties that have attainted great peer-esteem, and public research funding programs whose allocation criteria give weight to excellence and thereby provide high level administrators justifications for being seen to depart from risk averse institutional guidelines in order to accommodate those individual's pursuit of interesting research opportunities, therefore are affecting the formation of university-industry connections that are likely to give rise to future innovations. To appreciate the tangled lines of influence and indirect effects is to recognize why systems analysis is so necessary in the diagnosis of institutional problems and the design of corrective measures.

The perspective thus gained might be contrasted favorably with the thrust of the enthusiastic notice given by *The Lambert Review* (2003, p. 42) to the recent trend toward opening of "corporate liaison offices" at UK universities:

> Partly in recognition of the number and complexity of these [business-university] relationships, many universities have developed corporate or business liaison offices, with a specific remit to act as the interface with business. These offices have taken on an increasing number of tasks as universities' engagement with their wider community has developed. These include developing networks of businesses; marketing the research strengths of the university; advising on consultancy agreements and contract research; arranging complex collaborative research agreements or major joint ventures.

For the university to present business corporations' representatives with well-organized corporate academic face, and a central office whose concerns are regulation of external relationships and internal management control of the exploitation of the university's marketable "knowledge assets," may succeed in making European upper-level executives at both institutions feel increasing "at home" in their new contacts. Yet, this organizational measure strikes one as perhaps neither so important, nor so well-designed to respond to the challenge of drawing R&D managers and research personnel into dense and fruitful networks of knowledge-exchange with university-based experts.[51]

Viewed against these findings, the emphasis that was placed by the text of the *Lambert Review* upon the mission ("remit") of the newly established corporate liaison office to be the university "interface with business" is quite striking. To have a liaison officer advising firms of the formal requirements the university is going to impose upon consultancy agreements and contract research, particular those involving complex collaborative research agreements

[51] It is consequently a bit surprising to find the following statement, attributed to the Lambert Review in EC Staff Working Document [COM(2007), 161/2 :p.52, n.110]: "Indeed, 'the best forms of knowledge transfer involve human interaction', and European society would greatly benefit from the cross-fertilization between university and industry that flows from the promotion of inter-sectoral mobility."

certainly is appropriately instructive and when there is no room for flexibility. Yet putting this function in the hands of a central liaison office encourages pre-commitment of the university to the inflexibility of "standard-form contracts," and thus tends to reduce the scope for exploring a variety of possible legal arrangements the assignment of intellectual property rights, obligations and liabilities that would be responsive to the particular needs of the research collaborators, as well as the concerns of the participating corporate entities. Liaison officers, as the agents of university administrations, are likely to have much stronger career incentives to attend to the priorities of those responsible for monitoring and regulating and monitoring the formalities of the university's external transactions, than to seek ways of fulfilling the actual research *raison d'etre* that provide the impetus for the formation of successful and more sustained inter-organizational connections.[52]

4.5 THE UNPRODUCTIVE TENSION? RETHINKING IP OWNERSHIP AND RESEARCH COLLABORATION

There is thus an obvious tension between two key assertions about university-business interactions in many current policy recommendations, and in the programs that seek to respond to their advice. Insistence giving priority to "market-driven" technology transfers - based upon the licensing or direct exploitation of intellectual property arising from university research –creates impediments to inter-organizational collaboration, and, at very least tends to inhibit the recommendation that universities strive to develop more frequent inter-personal collaborative contacts to encourage exchange of scientific and technological information with industry. That this tension remained unresolved is not surprising, but that continued to pass without comment in policy circles for so long a time was nonetheless unfortunate. .

Most welcome, therefore is a recent shift of thinking that is evidenced in such statements as the one below, in which the view expressed by EC Staff Working Document [COM(2007), 161/2 :p.52] is in harmony with that in the 2005 report by the Forum on University-based Research:

> From a societal perspective, more will be gained by letting our universities excel in knowledge creation while encouraging closer links with the rest of society, than by insisting that they should fund themselves mainly through commercializing their knowledge.

This may intimate that the orientation of policy development for the ERA, particularly that aiming to "strengthen the link between the public research base and industry,"[53] is now moving into closer alignment with what appears to be the emergent trend in industry-university collaboration in the U.S. The latter, however, is not another new institutional model. Quite the opposite, in fact, as the signs are indicating a growing movement to recover a mode of interaction that seemed to have been all but lost in the post-Bayh-Dole era. One

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[52] These issues are examined at some detail in P.A. David and M. Spence, "Towards Institutional Infrastructures for e-Science: The Scope of the Challenges," (with M. Spence). A Report to the Joint Information Systems Committee of the Research Councils of Great Britain, *Oxford Internet Institute Report No. 2*. September 2003. [Available at: http://www.oii.ox.ac.uk/resources/publications/OIIRR_E-Science_0903.pdf.]

[53] The quoted phrase is the single most frequently cited national policy development among those listed in a country-by-country summary of the 25 EU member states' "National policies toward the Barcelona Objective," in European Commission, *Investing in research: an action plan for Europe*, Brussels EUR 20804 [COM92003) 226 final], Table 2.1, pp. 29ff.

harbinger of this trend-reversal might be seen in the recently announced Open Collaborative Research Program, under which I.B.M., Hewlett-Packard, Intel, and Cisco Systems and seven U.S. universities have agreed to embark on a series of collaborative software research undertakings in areas such as privacy, security and medical decision-making. The intriguing feature the agreement is the parties' commitment to make their research results freely and publicly available. Their avowed purpose in this is to able to begin cooperative work, by freeing themselves from the lengthy delays and costly, frustrating negotiations over IP rights that proposals for such collaborative projects typically encounter.[54]

This development reflects a growing sense in some corporate and university circles during the past five year that the Bayh-Dole legislation had allowed (and possibly encouraged) too great a swing of the pendulum towards intellectual property protection as the key to appropriating economic returns from public and private R&D investments alike; that the vigorous assertion of IP rights was being carried too far, so that it was impeding the arrangement of inter-organization collaborations involving researchers the private and publicly-funded spheres. As Stuart Feldman, I.B.M.'s vice-president for computer science, explained to the *NYTimes* reporter: **"**Universities have made life increasingly difficult to do research with them because of all the contractual issues around intellectual property….We would like the universities to open up again;" a computer scientist Purdue University echoed: "Universities want to protect their intellectual property but more and more see the importance of collaboration [with industry]."

Evidence of the effects of Bayh-Dole inspired legislation in the EU is beginning to appear and points to the negative effects that it may have. Thus a recent study has investigated the effect of the January 2000 Danish Law on University Patenting and found that it lead to a reduction in academic industry collaboration within Denmark[55]. This law, which transferred patent rights to the university employer of inventions produced by Danish university scientists acting alone or in collaboration with industry, had the further effect of increasing collaboration between Danish biotech firms and scientists working outside of Denmark. It is clear that the transfer of instituted rules from the USA to Europe is not to be treated lightly; their effects in different regimes may not correlate at all well.

How widely such views are shared, and how potent they may become altering the modus of industry university interactions that enhance "technology knowledge transfers", as distinguished from "technology ownership transfers," remains to seen. It is still much too early to venture speculations as to whether other institutions will follow, and it seems unlikely that those with substantial research programs in the life sciences and portfolios of biotechnology and medical device patents will find themselves impelled to do by the enthusiasm for such open collaboration agreements on the part of drug development firms and major pharmaceutical manufacturers.

From the societal viewpoint, the issue of whether IPR protection is getting in the way of the formation of fruitful collaborations between industry and university researchers is

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[54] See Stever Lohr, "I.B.M. and University Plan Collaboration," *New York Times*, 14 December, 2006. [Available at: http://www.nytimes.com/2006/12/14/technology/14blue.html.] The universities involved are U.C. Berkeley, Carnegie Mellon, Columbia University, U.C. Davis, Georgia Institute of Technology, Purdue University and Rutgers University.

[55] F. Valentin, and R.L. Jensen, 'Effects on Academia-Industry Collaboration of Extending University Property Rights', *Journal of Technology Transfer,* Vol.32, 2007: pp.251-276.

fundamental a question about the conditions that will maximize the marginal social rate of return on public investment in exploratory research, by making it more attractive for R&D-intensive firms with interests and capabilities in the potential commercial applications, to collaborate with publicly-funded academic research groups – in the hope of subsequently exploiting the knowledge-base thereby created. This issue is not un- related to an important aspect of the concerns that have been raised in regard to potential "anti-commons effects" of the academic patenting of research tools, and the resulting impediments to downstream R&D investment that are created not only by "blocking patents", but by "patent thickets" formed by a multiplicity of IP ownership rights that are quite likely to be distributed among different PROs. The latter would contribute to prospects of "royalty stacking" that would reduce the prospective revenues from a technically successful innovation, and to higher investment costs in due to the transactions costs of conducting extensive patent searches and multiple negotiations for the rights to use the necessary set of upstream patents. It would seem possible to address the source of this particular problem by allowing, or indeed encouraging the cooperative formation of efficient "common –use pools" of PRO patents on complementary collections of research tools. While this would strengthen the bargaining position of the collectivity of patent-owning institutions, and it would be necessary to have supervison of the competition authorities to present abuses, it might well increase the licensing of those technologies to downstream innovators. Of course, it is a second-best solution from the societal viewpoint, as the award of ownership rights on inventions that have resulted from publicly funded academic research will result in a "deadweight loss" -- due to the effect of the licensing charges that curtail the downstream exploitation of those inventions.[56]

The specific functionality of the information-disclosure norms and social organisation of open science that until very recently, by historical standards, was strongly associated with the ethos and conduct of academic, university-based research, rests upon the greater efficacy of data and information-sharing as a basis for the cooperative, cumulative generation of eventually reliable additions to the stock of knowledge. Treating new findings as tantamount to being in the public domain fully exploits the "public goods" properties that permit data and information to be concurrently shared in use and re-used indefinitely, and thus promotes faster growth of the stock of knowledge. This contrasts with the information control and access restrictions that generally are required in order to appropriate private material benefits from the possession of (scientific and technological) knowledge. In the proprietary research regime, discoveries and inventions must either be held secret or be "protected" by gaining

[56] There was, something not so foolish, after all, in the old-fashioned idea of upstream public science "feeding" down-stream research opportunities to innovative firms. The worries that this will not happen in the area of nanotechnology (see M. A. Lemley, "Patenting Nanotechnology", October, 2005 [available at: http://siepr.stanford.edu/programs/SST_Seminars/index.html] brings home the point about the unintended consequences of the success of national policies that aimed at building a university-based research capacity in that emerging field. The idea was not to allow domestic enterprise to be blocked by fundament patents owned by other countries. That they might now be blocked by the readiness of PRO's on their home terrain seeking to exploit their control of those tools is a disconcerting thought. For points of entry into the growing economics literature on the impact of academic patenting upon exploratory research investments, the "anti-commons" question (and the ambiguities of recent empirical evidence regarding its seriousness), patent thickets, royalty stacking, and efficient IP pools, see, e.g., P, A David, "The Economic Logic of 'Open Science' and the Balance between Private Property Rights and the Public Domain in Scientific Data and Information: A Primer," in *The Role of the Public Domain in Scientific and Technical Data and Information: A National Research Council Symposium*, J. Esanu and P. F. Uhlir, eds., Washington, D.C.: Academy Press, 2003; M. A. Lemley and C. Shapiro, "Royalty Stacking and Patent Hold-up," January, 2007 [available at: http://siepr.stanford.edu/programs/SST_Seminars/index.html] .

monopoly rights to their commercial exploitation. Otherwise, the unlimited entry of competing users could destroy the private profitability of investing in research and development.[57]

One may then say, somewhat baldly, that the regime of proprietary technology (*qua* social organisation) is conducive to the maximization of private wealth stocks that reflect current and expected future flows of economic rents (extra-normal profits). While the prospective award of exclusive "exploitation rights" have this effect by strengthening incentives for private investments in R&D and innovative commercialization based on the new information, the restrictions that IP monopolies impose on the use of that knowledge perversely curtail the social benefits that it will yield. By contrast, because open science (*qua* social organization) calls for liberal dissemination of new information, it is more conducive to both the maximization of the rate of growth of society's stocks of reliable knowledge and to raising the marginal social rate of return from research expenditures. But it, too, is a flawed institutional mechanism: rivalries for priority in the revelation of discoveries and inventions induce the withholding of information ("temporary suspension of cooperation") among close competitors in specific areas of ongoing research. Moreover, adherents to open science's disclosure norms cannot become economically self-sustaining: being obliged to quickly disclose what they learn and thereby to relinquish control over its economic exploitation, their research requires the support of charitable patrons or public funding agencies.

The two distinctive organisational regimes thus serve quite different purposes within a complex division of creative labour, purposes that are complementary and highly fruitful when they co-exist at the macro-institutional level. This functional juxtaposition suggests a logical explanation for their co-existence, and the perpetuation of institutional and cultural separations between the communities of researchers forming 'the Republic of Science' and those who are engaged in commercially-oriented R&D conducted under proprietary rules. Yet, these alternative resource allocation mechanisms are not entirely compatible within a common institutional setting; *a fortiori*, within same project organisation there will be an unstable competitive tension between the two and the tendency is for the more fragile, cooperative micro-level arrangements and incentives to be undermined.

5. POLICY FOR AN INNOVATION SYSTEM OR FOR A VIBRANT "ECOLOGY OF INNOVATION"?

We have explored in section 2 the claim that to form a system of innovation the organisations and the individuals in them have to interact in a way that contributes solutions to innovation problems. Systems depend on connections (interactions) and cannot be described or understood simply in terms of their components. What is at stake here is an idea that goes back to Alfred Marshall's concept of the internal and external organisation of a firm (in *Principles of Economics (8th edition) 1920, and Industry and Trade*, 1919). Flows of knowledge from outside its boundaries are important determinants of its capabilities and actions and any firm but this information is not simply 'in the ether' A firm has to invest in the organisation to gather this information and feed it into and adapt it to its internally generated information.

[57] This and the following discussion draw upon P. Dasgupta and P. A. David, "Toward a New Economics of Science," *Research Policy*, vol. 23, 1994: pp. 487-521, and P. A. David, "The Economic Logic of Open Science" (2003), loc.cit.

Innovative activity is perhaps the most important case of the firm's reliance on external sources of information, and leads to the idea that the firm is embedded in a wider matrix of relations that shape its ability to innovate. But it is important to recognise that a firm's internal and external organisation constitutes an operator that is simultaneously facilitating and constraining. The codes and information structuring routines that firms invest in to interact with other external sources of information also serve to filter and blinker the firm's appreciation of that information which is important and that which isn't (Arrow, 1974). Thus the innovation systems that a firm is part of are not always plastic in the face of changes in the knowledge environment; and, as a consequence, they do fail because their reading of new information is deficient. We should not loose sight of the probability that an innovation system generated to solve one set of problems may prove counterproductive in the context of a new and different set of problems, which is why the processes for assembling and disassembling specific innovation systems add greatly to the adaptability of any economy.

The policy problem may then be put starkly, "Is it possible to improve on the spontaneous self organisation process of the already existing and refined interaction between firms and PROs in Europe?" That the answer may be in the affirmative suggests that the innovation policy response fall into two related branches:

- Policy to improve the chances of innovation systems being formed from the ecologies of the Member States, a problem that is largely about barriers and incentives to collaborate in the solution of innovation problems.
- Policy to improve the quality of the knowledge ecologies in the Member States assessed in terms of the overall supply of researchers in different disciplines and the way in which they are organised to produce knowledge.

We have restricted our discussion in the preceding sections to the role of PROs in relation to these two policy problems, recognising two points throughout: the central role of firms in the realisation of innovations; and, the mix of market and non market interactions that shape the incentives, the available resources and the opportunities to innovate. Innovation, we repeat is more than a matter of invention and so it is particularly important not to equate innovation policy with policy for science and technology. University-business linkages form only part of this system and their influence on innovation cannot be independent of the many other factors at play. Thus the competitive implications of the single market will influence the incentives to innovate whether interpreted as opportunities or threats to a firm's position. Consequently, competition policy is *de facto* an important component of a broad innovation policy just as innovation policy is *de facto* an important component of competition policy. The fact that the knowledge ecology of the EU has been changing rapidly in the past two decades and that there are important differences in the richness of the ecologies in different Member States, adds further problems in understanding the implications for the innovation process.

On "connection barriers" and incentives for complementary interaction

We have hinted already - in sections 2 and 4 above- that the prevailing division of labour in the European knowledge ecology has not arisen by chance but rather as a reflection of many years of evolution in the comparative advantages of different organisations in producing and using knowledge. Firms, for example, have evolved in ways quite different to Universities because they perform different sets of tasks and fulfill quite different societal functions. This division of labour needs to be respected and understood, for it would be as foolish to make universities behave like firms as it would be economically disastrous to make private firms operate like universities. Their respective modes of operation are for a purpose. The origins of the current ecology, of which the governance of Universities are a part, can be traced back to a historical epoch when the knowledge foundations of industrial processes owed little to systematic scientific understanding and the formal organization and conduct of research and development activities. The modern age is different, however: the great expansion of organized public and private science and engineering research activities that took place during the second half of the twentieth century, and accelerated shift in the structures of the "industrialized" economies toward "services" and away from commodity production, are two important transformations that have in a sense made the university as an institution appear to be, at least outwardly, less distinct from other corporate entities than formerly was the case.[58]

The relevant issue remains how best to achieve co ordination of this division of labour and thereby enhance innovation processes. Here the different 'cultures' of business and the public research sector need special attention. The distinguishing feature of fundamental research in science and technology is its open nature, its nature as a science commons[59] Open science (including engineering technology) is a collective endeavour that bases the reliability of the knowledge production processes on widespread agreement as to methods of evaluation and replication but bases radical progress of knowledge on disagreement, the scientific equivalent of creative enterprise. This tension between order and agreement and change and disagreement is at the core of the institutions that shape science.

Similarly in regard to commercial innovation, disagreement is the defining characteristic of any significant innovative enterprise that is necessarily based on a conjecture that imagines that the economic world can be ordered differently. It is the open market system that facilitates adaptations to such disagreement and generates powerful incentives to disagree: the instituted procedures of Science and business are open 'experiment generating systems'; both work within different principles of order and both depend for their progress on the productive channeling of disagreement. The consequences are that the knowledge generating and using processes of businesses and of PROs, operate with different cultures, different value systems, different time frames, and different notions of what their principal activities are. Thus the principal outputs of universities are educated minds and new understandings the natural and artificial worlds, economy, society and so on. The outputs of business are different and involve new understandings of productive and commercial processes for the purpose of producing outputs of goods and services to be sold at a profit. Universities operate with one kind of governance system to achieve their aims, private firms with quite different governance systems and these differences materially influence their interactions in the pursuit of innovation. As pointed out in section 4 above, this results in very different norms for the production and sharing of knowledge within and between the two systems.

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[58] While this does not imply that other institutions and organizations are more interchangeable with the universities in the performance of a number of the latter's key functions in modern society, it has contributed to the recent tendency of some observers to suggest that universities as deliverers of research and training services might be more effective if they emulated business corporations that perform those tasks.

[59] R. Cook-Deegan, 'The Science Commons in Health Research: Structure, Function and Value', *Journal of Technology Transfer*, vol.32, 2007: pp.133-156; and R. R.Nelson, 'The Market Economy and the Scientific Commons', *Research Policy*, Vol. 33, 2004: pp. 455-471.

In both business and the academy positive feedback processes are in operation so that success breeds success. The profits from existing activities that provide the basis for subsequent innovation in a firm have their equivalent in the university in terms of research reputations that serve to attract high quality staff and funding. Indeed the institutions of science are partly designed to create and reinforce this process. The currently articulated attempts by some member states to accelerate this reputation effect through the competitive allocation of teaching and research funds are bound to further concentrate reputations on a relatively small number of universities.

Because there are strong potential complementarities between the conduct of exploratory, fundamental research in institutions organized on "open science" principle, and closed proprietary R&D activities in the private business sector, it is doubly important to establish market and non-market arrangements that facilitate information flows between the two kinds of organizations. The returns on public investment in research carried on by PROs can be captured through complementary, "valorizing" private R&D investments that are commercially-oriented, rather than by encouraging PRO's to engage in commercial exploitation of their knowledge resources. This is why the strategy that has been expressed in the EU's Barcelona targets is important: by raising the rate of *business* investment in R&D, Europe can more fully utilize the knowledge gained through its public research and training investments, and correspondingly capture the (spill-over) benefits that private producers and consumers derive from the application of advances in scientific and technological knowledge.

Knowledge transfer processes can be made more effective by attention to the arrangements that are in place at the two main points of the PROs' connections with their external environments. That any PRO may acquire the attributes of an isolated, inward-looking "ivory tower" is well understood, and their internal processes in many cases tend to encourage this. Universities in the EU frequently are criticized for operating with internal incentive structures that reward academic excellence in teaching and research independently of any potential application in practice. This concern is reflected in the newly attributed "Third Stream" or "Triangulation" of the University system, defined as "the explicit integration of an economic development mission with the traditional university activities of scholarship, research and teaching". [60]. Third Stream activities are of many different kinds, and here it is important to distinguish those activities that seek the commercialization of university research (technology licenses, joint ventures, spin offs etc) from activities of a more socio-political nature that include professional advice to policy makers, and contributions to cultural and social life.[61] What is significant about the current debate is the emphasis on the commercialization activities. What is less well understood is design of

[60] T. Minshull and B. Wicksteed, *University Spin-Out Companies: Starting to Fill the Evidence Gap*, Cambridge, SQW Ltd, 2005. Activities of this nature are not linked solely to academic and industry interactions. The tripartite missions in health care to link biomedical research with clinical service delivery and clinical education across hospitals and university medical schools have been widely adopted in the USA and UK. In the later they are known as Academic Clinical Partnerships and they provide the framework within which much NHS funded research is carried out. Segal Quince Wicksteed, 2006, *The Economic and Social Impact of UK Academic Clinical Partnerships*, Cambridge, sqw.co.uk.

[61] Observatory of the European University (OEU), '*Position Paper*', PRIME Network, 2007.

arrangements for commercialization that do not inhibit the research and teaching functions, the primary, of any university. To overcome the barriers to connecting PROs' research with commercial application by having those organizations become dependent upon commercialization of research findings, and behaving as a proprietary performer of R&D it is not sensible, as it would jeopardize the open science arrangements that are more effective for the conduct of fundamental, exploratory research – a function that must be fulfilled by some institution if a basis for long-run productivity growth is to be sustained.

This is only one of the difficulties with trying to reform PROs so that they are oriented not to supposed "ivory tower" solipsisms, but devote their resources mainly to the challenges of applied knowledge production and distribution. The heart of the problem lies in the difficulties of identifying those researchers and instructors that will be more likely to sustain highly original research (and teaching that poses both challenges and guidance to students), if the criteria for selecting them are strongly geared to their willingness to focus exclusively on addressing problems of the moment. This is a question of maintaining a balance of problem choice. If society's currently most pressing problems can be solved at all, they will in most cases be resolved by the application of existing knowledge – which itself will have resulted from fundamental advances that were made years ago, and subsequently tested by applications that will have greatly reduced the uncertainties surrounding their efficacy.

But, to follow and address the most pressing problems of the moment with that knowledge will necessarily involve public sector researchers in trying to work with, and accommodate the vital but often conflicting interests of other institutions and business interests in the society – for without that it is unlikely that workable and politically implementable solutions will be found. By engaging in that way, however, the university – as distinct from individuals who might engage in such efforts as private citizens, rather than as employees of a PRO – is likely to jeopardize its independence; or at least it is likely to be seen as the agent of one or another among the particular interests in the society, and thereby forfeit its claim to be capable of providing society with a source of independent information and analysis, free of partisan biases.

To overcome the forgoing "connections" barriers therefore requires firstly, the explicit creation of organisations fit for that purpose: intermediary organizations that can bridge between PROs with business across all possible known technologies. Secondly, it is necessary to institute changes in the PRO's internal incentive systems and regulations that will facilitate cooperation and regular interactions with those "bridge organizations". Many universities are seeking to do this and there has been a flowering of new organisational arrangements, incubators, spin-outs, university specific venture capital funds, etc, to respond to the innovation challenge. However, they are often hampered by the many pressures that currently affect their operation. These are problems that extend much beyond IPR issues and the extension of B-D arrangements to the European system. Some further elaboration of this point will help when we come below to the ecology dimension of the ERA. Other public research organisations, especially those with a mission-oriented, applied remit are less likely to suffer from the same problems as universities. Such organisations come in a rich variety of forms but they too may lack incentives to maintain the ability to engage with fundamental research.

6. Concluding Remarks

To attempt to summarise this lengthy discussion would not be wise but it is helpful to reiterate four of the main points that we believe should capture the attention of the relevant policy communities across the EU.

First we have emphasised that universities and other PROs are essential components of the ecologies that form the basis for the construction of specific innovation systems directed at particular problems. To a considerable degree universities make important connections with business firms and indeed have done so for many years. But, the pressures and changes that Europe's universities now face in markedly different innovation ecologies has raised questions that are focusing attention on the purposes and efficacy of the current extent and modes of university-business interactions.

Secondly, innovation ecologies only form into innovation systems when the different organisations from the ecology are connected for the purpose of solving innovation problems. Since universities and firms are part of a complex division of labour in which they have each evolved unique characteristics relative to their primary functions it is not to be wondered that the practices which support these functions do not automatically facilitate interactions among these differentiated organizations. Public and private policy therefore has an important role to play in respect of the richness and diversity of Europe's innovation ecology, and with respect to the ways in which connections can be formed and reformed to promote a higher rate of innovation.

Thirdly, the many instruments that have been designed to enhance the exploitation of university research are not necessarily the most beneficial ways of ensuring that university knowledge is translated into greater economic wealth. Models based on casual perceptions of how the innovation milieu in the economy can be quite misleading, and even when specific practices that are functional in that context are correctly understood, this does not mean that they can be selectively transplanted to the other shore of the Atlantic with good effect.

Fourthly, systems analysis perspectives have much to offer that is both insightful and necessary as a framework for the empirical research that should be a precursor to undertaking policy initiatives that may well have unanticipated and far-reaching consequences that disrupt and tax the resources of complex and in some cases fragile but nonetheless socially valuable institutions. Universities figure in that category, and pressures intended to induce these communities to take on new and different missions for which their historical evolution and specialized characteristics have not equipped them, run the risk of damaging their ability to fulfill critical functions that no other organizations in the society are prepared to perform will comparable effectiveness. The recognition of a need for new missions in the generation of transmission of knowledge suited to solve problems of innovation in the economy may therefore call for the development of alternative equally specialized bridging organizations that would gain expertise in the forging of diverse inter-organizational links between the worlds of the academy and the worlds of business.

It is appropriate to conclude this discussion on a note of qualification and caution that has been sounded in an essay on "The university in the learning economy" by Bengt-Åke Lundvall.[62] The

[62] B.-A. Lundvall, "The university in the learning economy," DRUID Working Paper No.02-06, University of Alborg, Denmark, 2006.

author makes the point that although great stress recently has been placed upon the economic significance of deep and regular interactions between business firms and universities, and policy discussions consequently have focused on institutional reforms and other measures intended to promote the forging of such links, achievement of that objective is not a necessary requirement or prerequisite that every country or region must fulfill if it is to achieve and sustain innovation-driven economic growth.

To illustrate this important *caveat,* Lundvall offers the counter-example of Danish industry, which by most of the indicators that are available for comparisons with other OECD countries, would appears to be at best linked only weakly with the country's universities. This observation applies both in regard to the degree of financial support that Denmark's HEIs find from sources in the private sector, and in measures of the extent of their involvement in cooperative research with domestic business firms. The question that this prompts is whether such a state of affairs should be viewed as constituting a problem for Denmark's economy and society, and the answer offered by Lundvall's essay is that, on the contrary, what it reflects are the set of specific characteristics of the system of innovation that has emerged in Denmark's industrial sector – namely,

1) a majority of small firms, and, by international standards, very few large firms;
2) a specialization of production and exports dominated by products with a low content of R&D;
3) a smallish proportion of private firms (25 percent) that have one or more employees with an academic training;
4) a high prevalence across most sectors, including so-called low technology sectors, of firms that appear to be quite innovative when it comes to products, processes and organisation, in which the dominating form of innovation is local incremental adaptation of products, but comparatively few who bring to the market really radical innovations that are new to the world market;
5) innovations that in most firms are rooted in practice and experience-based interactions among unskilled labor, skilled labor, technicians, designers and market-oriented expertise;
6) firm competences that more usually than not are built by recruiting people with a broad experience established in a flexible labor market; and through intense inter-firm co-operation --especially with customer and supplier firms in Denmark and other countries;
7) small and medium size companies that are operating at the higher-tech end of the spectrum of product and process design generally do not undertake much R&D on their own account, nor enter into close collaborations with public research organization, but instead make use of the country's technological advisory system -- which comprise both private management consultant firms and the state certified technological service (GTS-institutes), and therefore function to some degree as bridge-builders between the public research organizations and the science-based SMEs.

When viewed against this backdrop, the Danish pharmaceutical and biomedical sector stands out as being quite eccentric, with a small group of rather large corporations that are pursuing science-based programs of innovation and filing patents that frequently cite the results of private and public research organization. Lundvall (2006) remarks that because this atypical sector dominates the patenting activity of Denmark's firms, analysts at the OECD have been misled by their studies of the patent data to conclude that in the Danish economy there is a very close general linkage between innovative activity and scientific research organizations.

There are two important lessons that one should take from this particular story. First, although it justly may be said – and repeated often enough in these pages, that the establishment of connectivity among knowledgeable agents is a critical condition for innovation systems to emerge, it remains nonetheless true that the characteristics of the agents, and the nature of the knowledge bases whose conjunctions may yield effective a innovation system, are by no means going to be the same everywhere and in every era. For the dominant SME ranks of contemporary Denmark's industrial sector it is seen that personal interactions and information flows between specialized firms and their customers are especially critical, whereas such links as those businesses may find it profitable to establish with university-based research tend to be effected by intermediary "bridging" organizations.

Second, it clearly is necessary to continually question popular preconceptions about the existence of "one best way" for an organizational ecology to achieve the connectivities that will generate sustained innovative activity. Not only may such a consensus lack adequate empirical foundations, but adherence to "received wisdom" in matters of science and technology policy (no less than in other cognitive domains) can impose blinkers – restricted fields of vision and thought that prevent the discovery of a multiplicity of modes and pathways that would offer alternative ways of meeting the challenges of knowledge-driven economic transformation and growth.

ANNEX TO THE 3ND DRAFT REPORT

UNIVERSITIES AND PUBLIC RESEARCH ORGANIZATIONS IN THE ERA

Tables and Figures

Table 3.1 Key data on the higher education sector

	% of GERD performed by HES 2000-2005 (a)		Researchers in HES as % of national totals (FTE) 2000-2005 (b)		Researchers in HES (FTE) 2000-2005 (c)	
	2000 (1)	**2005 (2)**	**2000 (3)**	**2005 (4)**	**2000 (5)**	**2005 (6)**
European Union -25	20.9	22.2	37.0	36.6	398,548	445,780
Belgium (BE)	20.3	22.5	38.6	41.2	11,778	13,168
Bulgaria (BG)	9.6	10.0	19.9	25.9	1,886	2,607
Czech Republic (CZ)	14.0	16.2	27.2	31.3	3,768	7,576
Denmark (DK)	19.6	23.8	30.2	29.4	5,813	8,287
Germany (DE)	16.3	16.7	26.0	24.6	67,087	66,000
Estonia (EE)	52.5	41.5	67.7	57.2	1,806	1,905
Ireland(IE)	22.0	28.0	25.2	38.0	2,148	4,240
Greece(GR)	49.3	49.2	71.0	60.2	10,471	10,251
Spain (ES)	29.7	28.6	54.9	49.0	42,064	53,779
France FR)	18.6	19.7	35.8	32.7	61,583	65,498
Italy (IT)	30.5	32.7	38.9	39.2	25,696	28,226
Cyprus (CY)	25.0	37.5	42.2	59.5	128	375
Latvia (LV)	38.6	40.4	56.5	67.8	2,156	2,224
Lithuania (LT)	37.3	55.3	63.4	67.0	4,932	5,116
Grand Duchy of Luxembourg (LU)	0.0	1.3	1.3	8.4	22	176
Hungary (HU)	24.4	25.5	40.6	37.2	5,852	5,911
Malta (MT)	61.5	27.9	74.6	50.9	203	225
Netherlands (NL)	28.0	28.1	36.8	27.4	15,480	10,211
Austria (AT)	26.9	26.7	28.9	31.9	6,977	8,999
Poland (PL)	31.3	31.6	62.1	65.1	34,246	40,449
Portugal (PT)	36.8	39.5	51.3	53.0	8,592	11,138
Romania (RO)	10.8	10.3	12.4	26.6	2,542	5,654
Slovenia (SI)	16.8	9.8	30.9	19.4	1,340	742
Slovakia (SK)	9.2	19.6	50.3	59.1	5,009	6,458
Finland (FI)	18.0	19.0	..	32.5	10,405	12,879
Sweden (SE)	21.3	20.7	36.6	31.1	14,623	16,792
United Kingdom (GB)	20.4	23.1	22.7	..	29,000	..
United States (US)	11.4	13.5	14.7	..	186,027	..
China (excl. Hong Kong) (CN)	8.9	10.6	21.3	21.6	147,866	185,987
Japan (JN)	14.4	13.8	27.7	25.5	179,116	172,396

Source: (a) EUROSTAT, NewCronos Dataset, January 2007 extraction; (b) EUROSTAT, NewCronos Dataset, January 2007 extraction; (c) Notes: (1) 1999: GR, SE; 2002: AT, MT (2) 2004: IT, RO, NL, UK, US 2003: CN, JP (3) 1998: UK; 1999: DK, GR, SE, US; 2002: AT, MT (4) 2004: EU-25, FR, IT, RO; 2003: NL, CN, JP (5) 1998: UK; 1999: GR, SE, US; 2002: MT, AT (6) 2004: EU-25, FR, IT, RO; 2003: NL, CN, JP.

Table 3.5: University-industry knowledge transfer – a comparison between the US and EU

	EU (ASTP)	US (AUTM)	Ratio
Average research exp. (million US$)	*156.4*	*214.6*	
Invention disclosures	0.305	0.407	0.75
Patent applications	0.121	0.255	0.47
Patent granted	0.057	0.089	0.64
Licenses executed	0.134	0.115	1.17
Start-ups established	0.016	0.011	1.45

Source: The table is a compilation of the ProTon and ASTP surveys.[145]
Note: Figures given relating to invention disclosures, patent applications, etc. are all per million PPP$ of R&D expenditures

Source: Arundel and Bordoy (2006)

2006 ASTP SURVEY OF EU TTO's

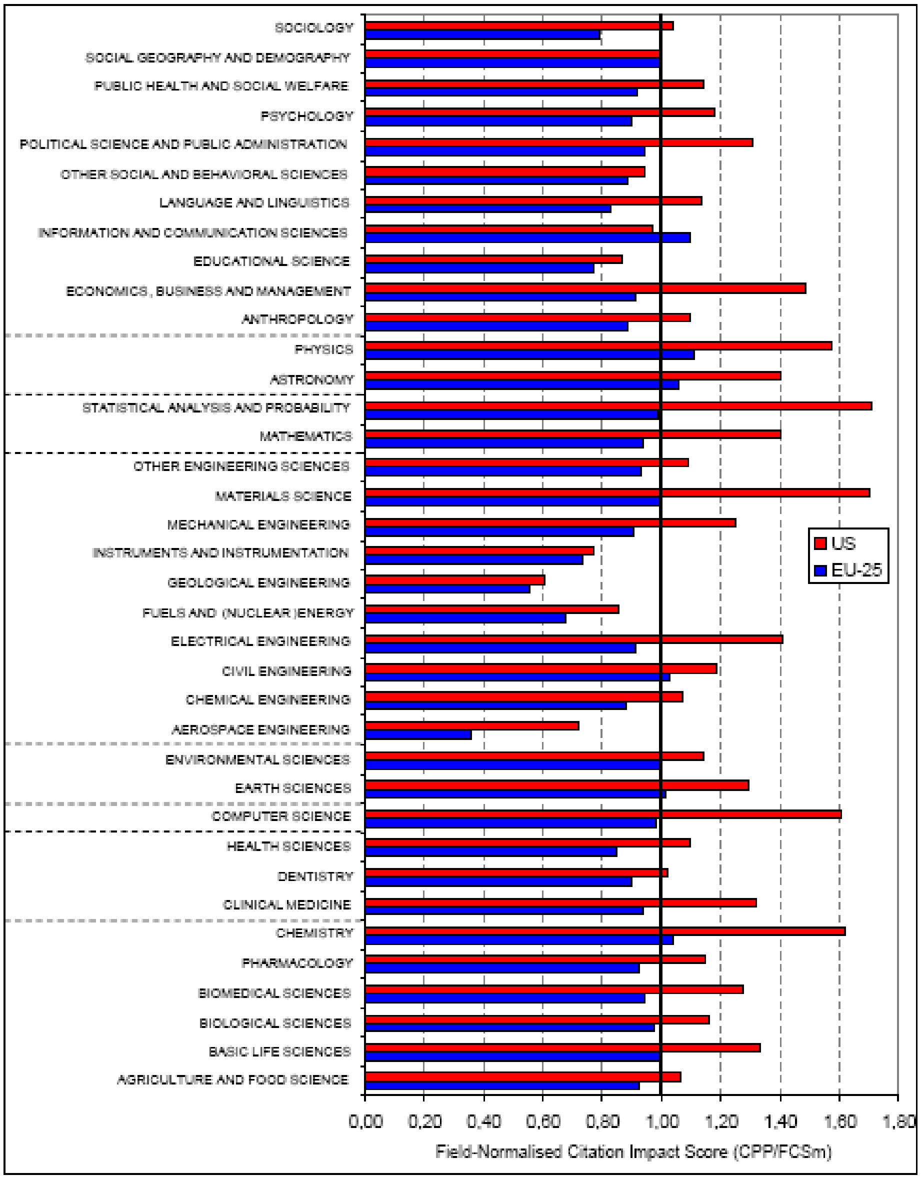
Table 4.14 Percent of R&D expenditures, R&D personnel, and seven performance measures accounted for by the top five institutions[1]

	2004 N[2]	2004 Percent total reported	2005 N[2]	2005 Percent total reported
Research expenditures	62	47.5%	55	49.7%
Research personnel	74	28.4%	72	30.5%
Performance measures				
Invention disclosures	84	34.2%	89	35.0%
Patent applications	83	41.6%	88	41.7%
Patent grants	65	54.7%	67	47.3%
License agreements	74	62.5%	82	57.9%
License income	56	82.9%	62	77.3%
Start ups established	83	26.3%	90	24.6%
R&D agreements	60	40.5%	65	39.5%

1: Top five institutions for each measure.
2: Number of respondents reporting results for each performance measure.

Source: Arundel and Bordoy (2006).

Figure 3.9: Field-normalised citation impact score per scientific discipline: the EU versus the US, 2002-2004.



Source: DG Research
Data: Thomson Scientific, processed by CWTS / Leiden University
Note: This graph refers to scientific articles published in 2002 and citations occurred in 2002, 2003 and 2004.

Table 3.1: Productivity Ranking - Publications

Year	AU	B	CA	Dk	Fin	F	G	I	NL	E	S	CH	UK	US
1987	7	13	5	12	1	4	3	8	9	6	11	10	2	1
1988	7	13	5	12	1	4	3	8	9	6	11	10	2	1
1989	7	13	5	12	1	4	3	8	9	6	11	10	2	1
1990	7	13	5	12	1	4	3	8	9	6	11	10	2	1
1991	7	13	5	12	1	4	3	8	9	6	11	10	2	1
1992	8	13	5	12	1	4	3	7	9	6	11	10	2	1
1993	8	13	5	12	1	4	3	7	9	6	11	10	2	1
1994	8	13	5	12	1	4	3	7	9	6	11	10	2	1
1995	8	13	5	12	1	4	3	7	9	6	11	10	2	1
1996	8	13	6	12	1	4	3	7	9	5	11	10	2	1
1997	8	13	6	12	1	4	3	7	9	5	11	10	2	1
1998	8	12	7	13	1	4	3	6	9	5	11	10	2	1
1999	8	12	7	13	1	4	3	6	9	5	11	10	2	1
2000	8	12	7	13	1	4	3	6	9	5	10	11	2	1
2001	8	12	7	13	1	4	3	6	9	5	10	11	2	1
2002	7	12	9	13	1	4	3	6	8	5	10	11	2	1

Key: Australia (AU), Belgium (B), Canada (CA), Denmark (Dk), Finland (Fin), France (F), Germany (G), Italy (I), Netherlands (NL), Spain (E), Sweden (S), Switzerland (CH), United Kingdom (UK) and United States (US).

Source: Crespi and Geuna (2004).

Comments:
The traditional productivity index referred to frequently and casually in science policy discussions is the ratio measure: "papers per $ of (current) HERD. Crespi and Geuna (2004: pp. 27-28) argue that this index is very incomplete proxy for research productivity, citing three main reasons:

First, the simple ratio does not control for other factors that affect the research outputs such as the way in which the resources are allocated,10 differences in the scientific opportunity and the effects of international knowledge spillovers.

Second, the simple paper per $ of HERD ratio does not considers the right denominator. The input is *the stock of domestic knowledge*, not the current HERD.Given the important lags in the research process, the research output in a given time is the result of a sequence of HERD investments carried out from years ago. Indeed, it is highly likely that the current HERD is not related at all with the current (observed) output.

This leads to the third drawback of the naive paper per $ of HERD ratio: it will be also strongly affected by the history of past investments in HERD by a given country. Finally, the paper per $ HERD ratio implicitly assume the existence of a linear relationship from input to output (the so-called constant returns to scale assumption). Crespi and Geuna find that this is not true and that decreasing returns are more likely. As a consequence the paper per $ HERD ratio will be also affected by the presence of scale effects, which means that one should be cautious when comparing nations with remarkably different volumes of scientific output.

Table 3.2: Changes in Relative Productivity: Publications

	Growth	SE	Constant	SE	Observations	R-squared
AU	-0.004	0.002**	2.165	0.017***	16	0.28
B	0.007	0.002***	1.730	0.016***	16	0.53
CA	-0.030	0.001***	2.557	0.010***	16	0.98
Dk	0.004	0.002*	1.768	0.0192***	16	0.19
Fin	0.012	0.002***	1.600	0.027***	16	0.54
F	0.004	0.002**	2.578	0.015***	16	0.26
G	0.001	0.002	2.672	0.0157***	16	0.02
I	0.013	0.001***	2.080	0.016***	16	0.79
NL	0.000	0.010	2.092	0.019***	16	0.01
E	0.011	0.002***	2.155	0.020***	16	0.66
S	0.013	0.002***	1.782	0.026***	16	0.61
CH	-0.001	0.002	1.963	0.015***	16	0.02
UK	-0.005	0.002**	3.061	0.019***	16	0.29
US	-0.025	0.001***	4.396	0.007***	16	0.99

Robust standard errors reported below each coefficient.
(*) significant at 10%; (**) significant at 5%; (***) significant at 1%

Source: Crespi and Geuna (2004).

Comments:
Because the rankings of countries by productivity level suggest stasis and can not reveal the dynamic process that may be affecting the relative productivity level, Crespi and Geuna (2004) compute the productivity growth rate of each country individually and then compare growth rate figures. They find from the results in the above table:

First, all countries except the US, Australia, Canada and UK have positive productivity growth rates (Switzerland shows an apparent decrease in productivity, but it is not significant). This means that all countries are converging towards the 'efficient frontier' represented in this set by the US.

Second, the convergence of the UK towards the US is mainly due to the deterioration in US productivity: the UK productivity growth rate also declines over the period, but at a slower pace than US productivity.

Third, the other countries are catching up to the UK because (with the exception of Canada) they exhibit a positive or zero growth rate or one that is decreasing less rapidly than the UK productivity growth rate.

Table 3.3: Productivity Ranking, Citations

Year	AU	B	CA	Dk	Fin	F	G	I	NL	E	S	CH	UK	US
1987	8	14	3	9	13	4	5	11	7	12	10	6	2	1
1988	8	14	4	9	13	3	5	11	7	12	10	6	2	1
1989	8	14	5	9	13	3	4	11	7	12	10	6	2	1
1990	8	14	6	9	13	3	4	11	7	12	10	5	2	1
1991	8	14	6	9	13	3	4	11	7	12	10	5	2	1
1992	9	14	6	8	13	4	3	11	7	12	10	5	2	1
1993	9	14	6	8	13	4	3	11	7	12	10	5	2	1
1994	9	14	6	8	13	4	3	11	7	12	10	5	2	1
1995	9	14	6	8	13	4	3	11	7	12	10	5	2	1
1996	9	14	7	8	13	4	3	11	6	12	10	5	2	1
1997	11	14	7	8	13	4	3	10	6	12	9	5	2	1
1998	12	14	8	7	13	4	3	9	6	11	10	5	2	1
1999	13	14	8	7	12	4	3	9	6	11	10	5	2	1
2000	13	14	11	7	12	4	3	8	6	10	9	5	2	1
2001	13	14	12	7	11	4	3	8	6	10	9	5	2	1
2002	12	14	13	7	11	4	3	8	6	9	10	5	2	1

Key: Australia (AU), Belgium (B), Canada (CA), Denmark (Dk), Finland (Fin), France (F), Germany (G), Italy (I), Netherlands (NL), Spain (E), Sweden (S), Switzerland (CH), United Kingdom (UK) and United States (US).

Source: Crespi and Geuna (2004).

Comments:

The results of a repetition of the productivity analysis with citations as the measure of national scientific output are qualitatively the as those found for publication counts, save that there is much more mobility in the middle and lower tail of the distribution. Western European countries tend in that range tend to move upwards in the ranking order, and advances are pronounced in the case of Denmark, Italy and Spain. Equally marked is the fall of Australia and Canada in these rankings.

Crespi and Geuna's analysis of the dynamics of these relative productivity indexes shows the same pattern of convergence toward the US and the UK as that found for the publication productivity measures. They point out, however, that whether the phenomena of catching up (or falling behind) displayed here represent a 'real' productivity increase (or decrease), rather than artefacts of the tendency for the countries that whose output is growing faster than the leaders are increasingly publishing in the journals included in the ISI Current Content archive, is an open debate. Their view is that the results probably do reflect the latter effect, because only the English-speaking countries show significant negative productivity growth rates. This is exactly what would be expected from a diffusion process in which many countries' scientists are publishing more frequently in English journals and, in particular, those on the ISI Current Content list. Thus the growth of English as the international scientific language may be rendering the spill-overs from other regions' research more accessible to the US, UK, Canada and Australia, but it is also undermining the apparent initial advantage in these measured productivity standings that was conferred upon them by the English language bias of the ISI archive of journals.