Academic Science in the UK: A Deconstruction

John Ziman

1. An apology

It was very disappointing that I was prevented at the last minute, by urgent and unexpected private matters, from attending the Augsburg meeting. I had been looking forward to discussing the situation of academic science in the UK with a group of well-informed but disinterested outsiders, and getting their reactions to our own ideas about what was happening, or should happen. At least there is some consolation in being asked to contribute this paper to the published proceedings.

I say "this paper", because it is not the paper I would have actually presented at Augsburg. There was no such paper. I intended to come only with a few OHP transparencies, to be talked about informally and off the cuff, just to provide a framework for the other British contributions and the debates that were bound to follow. What I write here is one of the many possible versions of that impromptu commentary. Here goes:

2. "Restructuring Academic Science"

It would be most immodest of me to accept the invitation to give this opening address if I were not, so to speak, standing on the shoulders of a team of giants. For most of 1989, a group of about 15 highly articulate people, with diversely authoritative knowledge of the British academic scene, worked together to generate the ideas that I put together as a Concept Paper of the Science Policy Support Group. What I have to say this evening is derived from the experience of producing **Restructuring Academic Science** - not just as finally written but also what I picked up along the way. If you have not already acquired a copy of "RAS", then you would probably be doing much better to sit down and read it through now than to attend to what I have to say.

A spoken account of a complicated subject does have the advantage, however, that it can be complemented visually. Even the most craftily illustrated written text cannot compete with a simultaneous audio/visual

presentation. The images that I am now going to present and discuss only cover a fraction of what is said in **RAS**, but they do convey a number of the points that we thought the most significant. They are, if you like "mental models" of certain aspects of the system.

3. Framing "Academic Science"

The first point scarcely needs to be illustrated. In the UK, as in other advanced countries, an elaborate system of institutions has evolved to perform basic or strategic research whose outcome is not, or was not originally, expected to be put to immediate practical use. That is what I mean by "Academic Science".

Never mind the precise definition of this activity. The current fashion in official science policy circles is to refer to it as "The Science Base", but that does not help to draw a line where (to use more of the official jargon) it merges, say, into pre-competitive research for the development of generic near-market technologies, etc.

It is more important to **frame** our topic realistically than to define if formally. One of the characteristic features of academic science is that its output goes mainly into the domain of "Public Knowledge". We take it as given that academic scientists in the UK will continue to contribute to the world market in scientific knowledge, and to compete successfully for international recognition for their work.

Another boundary condition must be the requirement to generate increasing amounts of knowledge that can be exploited for the benefit of industry, health, environmental quality, and so on. It would be nice to assume that the resources to meet this demand will also be forthcoming, but that is not the way things look in the UK at the present time. This edge of the frame is fixed. For reasons discussed at length in our earlier SPSG Concept Paper, "Science in a 'Steady State'", the assumption has to be that most of the funding for the Science Base will continue to come from the public purse, to a total of between 1 and 1.5 billion pounds. I also assume that this sum will continue to be divided up and allocated according to broad national priorities by some sort of central policy machinery, involving bodies such as the Advisory Council for Science and Technology (ACOST), the Advisory Board for the Research Councils (ABRC), the Universities Funding Council (UFC), the individual Research Councils (RCs), and various government departments. It is true that this tree-tops machinery is also undergoing struc-

tural change, but not at a rate that significantly affects the turmoil at ground level and in the grassroots of the system.

The final, fourth edge of this frame is more contentious. Academic research work in the UK has largely been carried out in close association with undergraduate education. In some disciplines, such as medicine and agriculture, separate research establishments staffed by full-time researchers have played, and continue to play, a major part, but the general tendency now is either to privatise these or to bring them back on to the university campus. The fundamental structural issue for academic science in the UK is not whether or not it should remain largely in "Academia", but just how closely it should be linked with its Siamese Twin - academic teaching.

The trouble is that if we were to carry our analysis over to the other side of this relationship, we should find ourselves in an unbounded area of chaos and dispute. The whole issue of the funding of higher education in the UK has become a political football which gets a kick in a completely new direction every few months. If we are to avoid being drawn into that mad stadium, we must just complete our frame with the arbitrary assumption that universities and other HEIs will continue to exist as teaching institutions, more or less as at present, and that they will receive from the government, from their students or from other unspecified pots of gold, the funds they need to perform that function.

4. Not so much a blueprint as a scenario

Much of the talk that goes on about "restructuring" suggests a firm intention to design a rational system, set it up, and set it going. It sounds as if somebody - not us, chum, but "them", in Whitehall or somewhere - is going to produce a blueprint and do some social engineering to put it in place. Well, social engineering is distinctly out of fashion these days. What will really happen is that Ministers, the Treasury, various officials, the UFC and other powerful actors will push and shove and cause changes to happen, without any concerted plan, or even any consistency in their views on how the system might look after they have done their work. **Bricolage**, you might call it, or "bodging" - which is not, I may say, a term of abuse in the countryside where I live.

What we tried to do in RAS was simply to produce a realistic "scenario" showing how the system might look in the mid 1990s. To some extent this is an extrapolation of current trends, but it is not a prediction or a plan of

action. It does not even have the usual list of "policy recommendations", since its goals are strategic, not tactical.

All it does is to show that many current trends of policy and practice could be reconciled with other desirable features to produce a consistent, effective system. But there must be many other ways of achieving essentially the same ends, provided that we are reasonably clear what these ends ought to be. In other words, it is primarily an exercise in deconstruction, designed to uncover critical points for further research and analysis and to provide a coherent framework for all the decision-making that will need to be done, at all levels, over the next few years.

5. Structural principles

At this point, to demonstrate that I was still perfectly sober, I would show a transparency setting out the 'structural principles" that our academic system ought to satisfy. But this list is so trite, so infused with the twin spirits of market macho and managerial motherhood, that I would just flash it up, to give you an idea of the climate in which we are now working. Here it is, for what it is worth, as concisely as I can express it:

STRUCTURAL PRINCIPLES

Accountability for resources used

Evaluation of projects, performers and products

Competition for resources in terms of quality

Devolution of managerial and technical responsibilities

Adaptability of individuals and organisations

Opportunity for enterprise and for the exploitation of discoveries

Coordination of research efforts through collaboration and shared facilities

Yes, these are fine principles. Only they have to be implemented without overriding the requirements of creative scientific activity, such as:

- openness to innovation and criticism;
- space and time for new ideas to emerge and mature;
- recognition for personal achievement;
- respect for established expertise.

6. Researchers

The proper place to start any study of a research system is with the researchers. The central fact of academic life in the UK is the overlap between teaching and research. As anybody who has worked in higher education knows, this is really a very complicated matter.

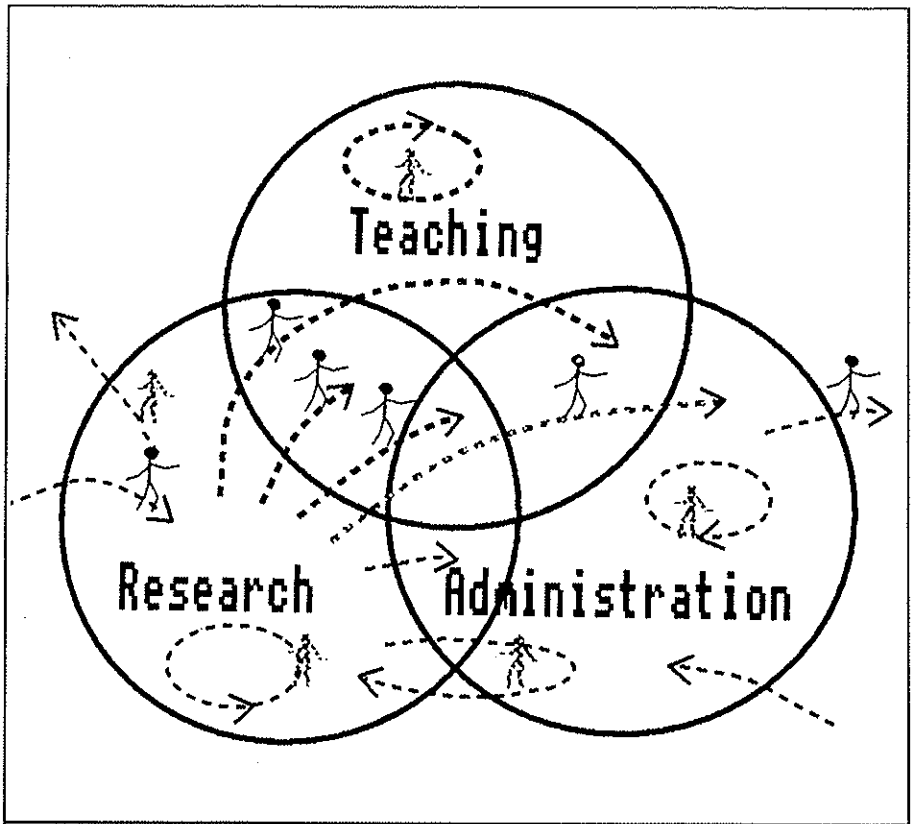

Figure 1: Career paths in Academia

In the first place, there is a third area of activity - "administration". This includes much more than the "management" of education, research or other institutional sub-divisions. There are lecture lists to arrange, students to select, counsel, and examine, projects to plan, apply for and oversee, finances to be accounted for, etc. In a modern university of high standing, this type of work, broadly interpreted, may well take up as many professional person-days as either teaching or research.

Secondly, a relatively small proportion of the academically qualified staff of an HEI follow the stereotypical scholarly career, starting in research, then moving into a combination of research and teaching, with the addition of

increasingly burdensome administrative responsibilities until a well-merited retirement.

What we observe in practice is an immense variety of career paths though these overlapping domains. Some people just stay in research, or are kept in it against their aspirations by a sequence of short term contracts. Some give up research altogether and spend their days in teaching and administration. Some become pure administrators. Some are never anything but teachers. Some leave academia for industry, consultancy work, or other employment. Some enter HEIs as researchers or administrators.

I have a feeling that every one of the logically distinct paths on this simple Venn diagram has its counterpart amongst the careers of academic staff in the UK today.
To say, therefore, that academics spend about one third of their time, on the average, on each of these activities is totally misleading. In reality, individuals vary enormously in how they divide their time between these activities, and they often change the mixture radically in the course of their careers.

Let me say at once that this diversity of permissible career paths, which is a traditional feature of UK academic science, has many advantages. In particular it satisfies the basic structural principles of **Adaptability** and **Opportunity**, as they apply to the individual. But the informality, the idiosyncracy - sometimes the self-deception - of these career preferences introduces a major element of unaccountability into the system.

The government has already decreed the end of academic tenure - that is, permanent employment to retirement age in a post with almost undefined duties. From now on, it is likely that all the staff of HEIs will be on limited term contracts, normally renewable and protected from arbitrary termination, but with somewhat stronger conditions of employment. The time has come, in my opinion, to specify in the employment contract of each individual employee the time division between teaching, research and administration, and to insist that this condition, in broad terms, is adhered to.

Let me emphasise that this division of time should not be the same for all academic staff, and should not be the same throughout the career of any one person. On the contrary, it should vary widely from individual to individual, and from stage to stage in each career, just as it does now. But these variations and changes should be matters for explicit negotiation between HEIs and their staff members, in accordance with the best interests of both parties.

Why is this so desirable? The first reason, to which I shall return, is to improve financial accountability for the research actually undertaken by the HEI. It seems impossible to produce a rational scheme for the funding of academic research if one cannot include reasonable figures for the cost of academic staff time.

The second reason is that the time that an employee of an institution spends on research is effectively a charge on the resources of the institution - especially if it implies the use of expensive research facilities with large overheads. The principle of **Evaluation** requires the periodic appraisal of individual academic staff for their performance and prospects in teaching and research. What would be the point of such an appraisal except as a basis for a decision on the relative amounts of research, teaching and other work to be done by each individual for the institution?

7. Research entities

Research nowadays is seldom done by isolated individuals: "lonely seekers after truth". Even when it does not involve a number of researchers working together as a team on the same project, it is usually organised in "groups", or "units" specialising in a particular field and undertaking closely related projects with the same material and conceptual apparatus.

These "research entities", as I shall call them, are extraordinarily diverse in size, composition and organisational location. This last is particularly significant. As we have seen, many of the researchers in academic science are also busily teaching their subjects to undergraduates. Undergraduate teaching in most HEIs is organised in "departments", usually in terms of the traditional academic disciplines. Thus, an academic who is active in both teaching and research is based simultaneously in two different organisational sub-units of the HEI. The relationship between research entities and teaching departments is thus a major structural factor in academic science.

But as we see in Figure 2, this relationship is extraordinarily varied. Sometimes (a) it is just one scholar working alone. Sometimes (b) it is an interdisciplinary group, with members drawn from several departments. A research entity (c) may include all the members of a small department, but more commonly (d) it will be a sub-set of them. One should not exclude research entities (e) in which researchers from several institutions work closely together. A major research facility, such as a radio telescope (f) may house research entities with members teaching in a number of HEIs. Or it may happen (g) that several research entities in several departments are effec-

tively linked in a larger grouping with its own organisational identity. Finally - and quite commonly - there are teaching departments (h) whose members are not involved in research, and are therefore outside the research entity system.

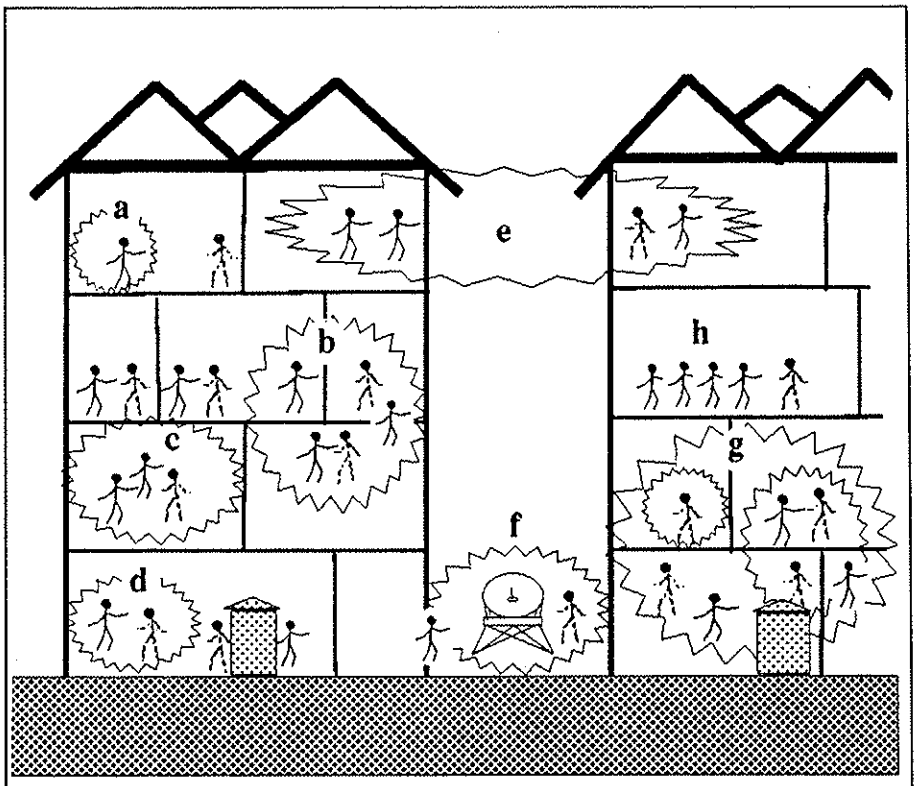

Figure 2: Various types of research entity

Official talk in the UK has fastened on what they call an Interdisciplinary Research Centre - an IRC - as the new organisational model for academic research. But this is only one of the many different types of organisational entity that have already evolved in our scientific community. This development was never deliberately planned: it has occurred naturally, through the

initiatives of individual researchers, educational institutions and funding bodies to facilitate collaborative research on scientific or technological problems of current interest.

It would be a disaster if the restructuring process were to interfere with this development. What is needed is not an official prescription for new research entities but a set of guidelines within which they may emerge, evolve - and gracefully wither away - as circumstances demand.

What we suggested in RAS can be summarised as follows:

- A research entity should not be regarded as a permanent organisation with an independent corporate identity, but should belong legally, financially and managerially to the parent HEI.

- On the other hand, whilst it exists it should have considerable autonomy in developing its own programme of research, seeking support for it from external bodies, and directing it operationally.

- It should account to the parent HEI for the resources it uses and other costs, including indirect costs, overheads, and the proportion of the working time of its academic staff members that is devoted to its research activities.

- Grant and contract money received by the HEI for this research should be credited to the research entity to set against these costs.

- All aspects of the performance of a research entity should besystematically evaluated, and periodically reviewed, jointly by the parent HEI and the principal patrons of its research programmes.

- It is the responsibility of the parent HEI to foster new research entities as the need for them emerges, to provide capital and research facilities for them, to help them negotiate support from funding bodies, and - above all - to close them down when they become obsolete.

It would take too long to explain the rationale of these guidelines. But I should say that I am under no illusions about the difficulty of putting them into practice. By returning to individual universities and other HEIs their traditional responsibility for the detailed organisation of research, they conform to current trends favouring decentralisation and devolution. But they run counter to the **dirigiste** spirit that increasingly permeates the bodies that dispense public funds to research.

Within each HEI also, these guidelines challenge the managerial responsibilities of faculties and teaching departments organised on disciplinary lines. Nevertheless, I believe that the development of complex matrix structures of this kind is essential if we want to preserve the British academic tradition of combining teaching and research activities by the same persons under the same roof.

8. Funding Research

Now let us look at the machinery for distributing resources to researchers and research entities.

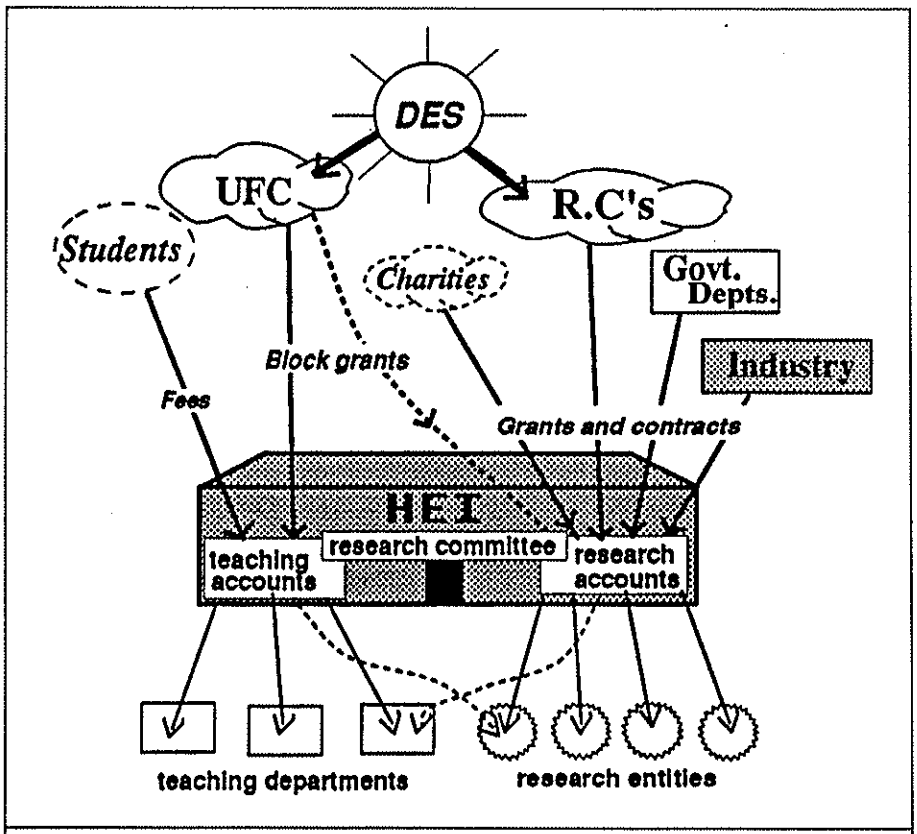

Figure 3: Funding of Teaching and Research

At first sight, this seems very complicated, but really there is only one major source of funds for academic science in the UK - the Department of Education and Science (DES). It is true that a large proportion of the medical research is supported by charitable foundations, that other government departments commission research from HEIs, and that industrial firms are increasingly funding academic research related to their products. But the system is structured around the procedures by which public funds flow from the Treasury, through the DES, and then down to HEIs and into their internal organs.

The real complication in this picture arises from the attempt to retain a very peculiar British device: the "Dual Support Principle". The roots of this principle reach deep into the past, to a golden age when there was a beneficent body called the University Grants Committee - the UGC - which allocated a great gob of money to each university on the tacit understanding that it would spend it wisely on teaching and research. In other words, academic research was funded indirectly, without detailed accountability, through a series of institutional block grants, whose amount, incidentally, was decided quinquennially.

In the modern era, however, the other leg of the system developed, mainly to provide the additional resources required for research in the natural sciences and their associated technologies. The research council system was expanded and fattened with funds to be allocated to HEIs for laboratory equipment, technical staff, additional research assistants, as well as for national facilities and specialised research establishments.

In these post-modern times, we have a situation where the actual resources used in academic research come in roughly equal quantities from these two subsidiaries of the DES. The part that comes through the research councils is distributed in the form of innumerable research grants or contracts, each amounting to a few tens or hundreds of thousands of pounds over periods of three years or less. The part that comes from the UFC (for all practical purposes, the UGC under new management) still arrives at each university as a minor fraction of a block grant of tens of millions of pounds, the rest of which is intended to cover most of the institutional costs of undergraduate instruction.

I call this the post-modern era, because all is in flux, and all the old certainties are being challenged. There is still a strong (?sentimental?) attachment to the dual support principle, although everyone agrees that it has broken down. I shall not try to describe the current UFC effort to fix it by an elaborate combination of "research performance evaluation" and "formula

funding", partly because I am not sympathetic to it - at least as far as I can grasp its underlying rationale - and partly because I do not believe that the system can last in anything like the present form. In any case, you will surely hear all you could possibly want to know about this bit of policy bodging from other contributors to this meeting.

The scenario we envisaged in RAS is somewhat more radical. Paradoxically, it proposes to protect the actual symbiosis of teaching and research in our HEIs from the fatal ambivalences of the dual support principle by explicitly separating them in budgetary terms.

At the institutional level, this means the preparation of separate accounts for teaching departments on the one hand, and research entities on the other. Although items for the stipends of many members of academic staff will appear on both sets of accounts, they will be proportioned according to the time that each person has contracted to give to these different activities. The same will apply (as it already does in some go-ahead institutions) to the costing of buildings, services, and other indirect costs and overheads.

I am not suggesting that this is a trivial or uncontroversial exercise in accountancy, since it will obviously affect the actual allocation of scarce resources within each institution. But it is the only way of defending the practices that many of us regard as effective and economical from the demand for much greater accountability in the use of "the taxpayer's money", as they sententiously call it.

Once this is done, the way is clear for a similar separation at the DES level - that is, by transferring the research component of the UFC block grants to the research council system, where it can be used to cover the additional overheads, indirect costs, and academic staff time that universities will have to charge on research projects. A step in this direction has already been made by the DES, but they will have to go the whole hog in the end.

Again, the supporters and bodgers of dual support can raise many objections to this proposal. They can talk about the problem of separating research from teaching costs in dual function organisations, about the creative accountancy required to determine overhead costs and allocate them fairly, about the very real difficulties faced by charitable bodies whose funding of academic research has been tacitly subsidised by the block grant procedure - and so on.

In my opinion, these objections are outweighed by two major benefits. In the first place, all research projects, programmes, entities, centres, facilities, etc.

within HEIs will be funded at full cost. In the current jargon, the playing field will be at the same level for all research customers, whether they are research councils wanting to buy basic or strategic research, government departments commissioning shorter-term policy studies, industrial firms establishing entry points into academic science, or even the European Commission fostering international collaboration in research and development. If market forces are to operate uniformly across the national research system, then arbitrary variations in the costing of projects to different classes of customers can no longer be tolerated.

The other benefit of the RAS scenario is that it provides much clearer and more direct channels for the evaluation of research quality and capabilities. In practice, research is not proposed or performed by universities or by their internal "cost centres": it is proposed and performed by research entities. Although I have shown research council funds flowing into the central research accounts of each HEI - which is where the cheques are legally credited - the reality is that the terms of these research grants and contracts are negotiated with the specialised research entities who have submitted projects or have been invited to undertake them.

The truly effective way to monitor, foster, reward, select for, or eliminate the weaknesses in, research quality is through these channels. This is not to say that the present system of ex ante peer review of research proposals is the ideal way of evaluating academic science. Far from it. For many purposes, periodic ex post assessments of the performance and capabilities of individuals and research entities would be more rational and more effective. The essential point is that selectivity for research excellence must be the responsibility of those bodies with the greatest competence and highest stake in assessing it - the specialised "customers" and "patrons" who support it financially.

There is a more subtle argument for the separation of teaching from research at the higher levels of the education system. It can be summed up as follows: **research policy should be designed to reinforce success; educational policy should be concerned with strengthening the areas of weakness.** The indicator of the effectiveness of a research system is the outstanding discovery, the scientific or technological "breakthrough", the swift exploitation of unforeseen opportunities. In research, quality is always more important than quantity. The indicator of the effectiveness of an educational system is a uniform high level of graduates, encouragement and support for the less capable students, teachers and institutions. Education must have quantity as well as quality, to meet the extensive needs of society.

The diametrically opposite strategies thus advised produce confusion when they are applied to a mixed system. Should a relatively weak university be closed down because it is contributing so little to research, or should it be given extra resources to improve the teaching of the thousands of students who need the education it could give? Should research funds be distributed widely to academics who are competent teachers but indifferent researchers, or should they be concentrated in centres of research excellence such as Oxford and Cambridge? Such dilemmas cannot be resolved whilst these two threads of policy are so entwined.

9. Linking the markets

The question I now want to raise is this: the various components of the UK science base are in quite fierce competition with one another in a number of different "markets": do these various modes of competition interact constructively, and can they be reconciled with the requirements for cooperation and coordination in the scientific enterprise? I have to admit that I have been giving some further thought to this question in the month since the Augsburg meeting, so what I now say may not be quite what I would have said then.

Figure 4 represents this competitive situation veryschematically. First notice that it is not confined to the UK. All the markets we are talking about are now world-wide in their scope, although current policy emphasises the importance of the European Community as an area where competitive forces are to be given a free rein. This competition operates at three levels:

(1) Individual researchers are still in fierce competition with one another for academic jobs and for scholarly esteem. Ever since the days of Newton v. Leibniz, scientists have vied with one another for tangible or intangible "recognition". The involvement of academic scientists in the traditional "reputation market" of the international scientific community is still the most potent social instrument for generating effort and excellence.

(2) Research entities compete directly with one another for research grants and contracts. They are involved in a series of specialised, interlinked "project markets", where they offer their services as research contractors to funding bodies acting as discriminating customers. Here again, strong competition in terms of quality (e.g., a substantial margin of "unfunded alphas") is undoubtedly beneficial, although one should be worried at the tendency towards monopsony - that is, where the potential customers

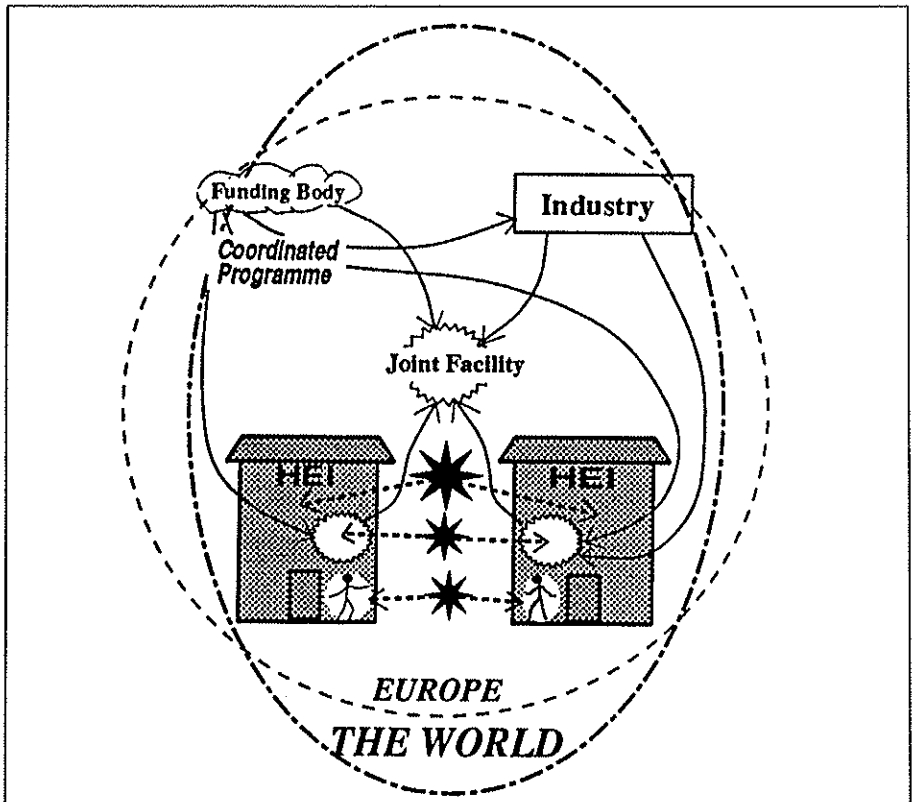

Figure 4: Competition and cooperation

for a particular research project are limited to, say, just one research council and a charitable foundation.

(3) Finally, there is the straightforward commercial competition between HEIs for research and teaching funds. This is what most people have in mind when they insist that "market forces" should have much more sway in our HE system. On the whole, our RAS scenario supports this development, although without the additional supposition that if only a university were more like an industrial firm it would be more efficient in every way. A competitive market system is not only an effective means of keeping institutions on their toes: it is also their only route to freedom from the managerial tendencies of the UFC.

How well do these various markets mesh together? It seems to me that some of the internal tensions within HEIs are symptoms of the conflicting demands of these very diverse markets. For example, the conditions that are now customarily written into research contracts to cover intellectual property rights (IPRs) may favour the institution in a commercial sense, at the expense of the reputation of the researcher or research entity. Also, I am not at all sure of the wisdom of the attempt of the UGC to reward institutions in hard cash (through the "JR" term in the block grant formula) for the intangible "reputational" standing of its academic staff. These are more subtle matters than some of our notables seem to realise.

Competition is not, however, the only name of the scientific game. Scientific progress depends equally on **cooperation** in research. This takes various forms, from the loose coordination of cognate projects to tightly managed collaboration and teamwork.

Under ideal circumstances, arrangements for working together evolve through the voluntary pooling of effort by independent researchers and research entities. In practice, however, cooperation is difficult to initiate unless it has an organisational base.

This is where national funding bodies have a responsible role to play. Through their specialised subject committees they are directly in touch with the corresponding research communities throughout the country, and are thus in a position to foster collective initiatives, such as the establishment of joint research facilities, which would be beyond the means of any single research entity or its parent HEI. This is, of course, a well-established practice of the UK research councils, typified currently by the fashion for setting up IRCs.

All that I wanted to say on this point here is that quite delicate questions of protocol can arise for research entities, as their relationships are switched back and forth between the competitive and cooperative modes. In the restructured scenario, one would expect funding bodies - national and international - to have laid down careful guidelines on the development and monitoring of coordinated programmes or collaborative projects, so as to protect the competitive concerns of the participating researchers.

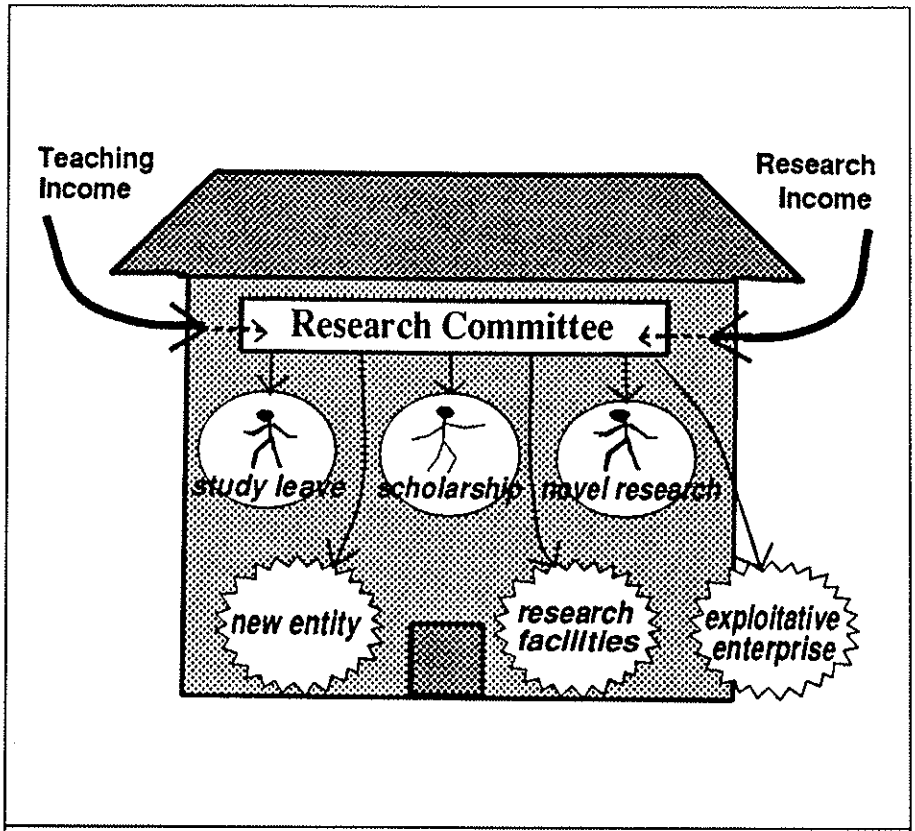

Figure 5: Career and institutional development

My final picture represents an institutional development which may have a more significant role than we originally assigned to it in RAS. According to the official doctrine, every HEI should have a "research committee" to oversee its activities in that area. Now one has to be careful about this, since it could mean that the central authorities of the HEI were usurping the technical autonomy of its research entities, or even trying to second guess the expert decisions of external funding bodies.

What we suggested was that a body such as this could play a valuable part in allocating resources internally for a number of functions which should not be the direct concern of external bodies such as research councils. These functions, as indicated in Figure 5, include:

- grants to individual staff members - typically in the socialsciences and humanities - to cover the personal costs of their research, including study leave, attendance at conferences, communication facilities, etc.;

- similar grants, especially to staff members heavily involved in teaching, for what is called "scholarship', that is, study, travel, curriculum development, subject reviews, etc., which would not, strictly speaking, be classed as "research";

- support for small, novel research projects, especially those proposed by junior members of staff who are not yet established in the national project marketplace;

- seeding and start-up costs of new research entities;

- capital and core funding for the facilities and infrastructures needed inside the institution for research;

- venture capital for small enterprises to exploit commercially the research work done inside the HEI.

At first sight, this looks rather a rag-bag of functions, but they have the common purpose of ensuring the development and renewal of the institution /and its staff. This is particularly important for those HEIs - typically, in the UK, polytechnics - where most members of staff are not actively involved in serious research, and need alternative modes of intellectual stimulus and career development. But it is also essential for a university with a high research profile to be able to shape its own scientific future by fostering bright young scientists and bright ideas for research.

The important structural point about this proposal is that this committee should be central to the institution, and not devolve its budgets and decisions to faculties, teaching departments or research entities. It should, so to speak, be the forum for an internal market, where individuals or small groups submit proposals and compete for funds.

The amount and source of these funds is a much more open question, since it must depend, eventually, on the final fate of the dual support system. In principle, all these functions could and should be financed out of UGC/UFC block grants: in practice, over the last decade or so, this type of activity has been largely marginalised by the desperate need for funds simply to keep institutions going. For this reason, we would derive these funds from, say, a statutory "tax" on the teaching and research income of the HEI, earmarked for these specific purposes but not to be accounted for in detail to external bodies. The DES has interfered much less wisely than this in the affairs of the institutions that it supports!

I have now come to the view that some structural arrangement of this kind is essential to temper the effects of market forces. What I mean is that fierce competition, whether for grants or for reputation, is strengthening for the strong, but very damaging to the weak. It can make it very difficult for newcomers to get established, and equally difficult for those who have failed to make an honourable exit to more constructive work. The "research committee" can be considered a means of easing the way for individuals into and out of the academic marketplace, without compromising its competitive standards.

11. Final remarks

By this time, surely, I would have gone on much too long, and be well advised to shut up and sit down. I would still have two more transparencies to show, listing five "crunch points" of the system, and "some food for further thought". But really it is an enormous topic, which cannot be closed off so cavalierly. So I cheerfully give the floor now to other people who know much more about this topic than I do, and certainly have thoughtful opinions which we would all want to hear.

Author's address:

Professor Dr. John Ziman
Science Policy Support Group
22 Henrietta Street

London WC2E 8NA