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The origin and evolution of the university species

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INTRODUCTION

The university – "To be or not to be?"

What does the future hold for the university? Two very contradictory theses have been put forward. On the one hand, there is the 'declinist' thesis, with some pessimists believing that the very future of the university is under threat from governments and others expecting universities to do more useful things – to produce more applied knowledge, to develop more useful skills in its students. Such a trend is seen as potentially threatening the very integrity of the university along with its long-cherished autonomy. There is also believed to be an emerging threat in the form of new entrants to the higher education 'market' – from companies coming in with electronic courses and other forms of electronically mediated distance learning.

On the other hand, there is the optimistic thesis. According to this, we are moving into the so-called 'knowledge-based economy' or 'knowledge society' (e.g. Stehr, 1994). In such a world,

> ... the knowledge industry in modern societies is no longer a minor affair run by an intellectual elites, an activity that might be considered by pragmatic leaders as expendable; it is a mammoth enterprise on a par with heavy industry, and just as necessary to the country in which it is situated (Graham, 1998, quoted in Etzkowitz et al., 2000, p.329)

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In this changed environment, universities, as arguably the primary source of new knowledge and of the skills that are required for a knowledge economy, could become the 'engine' of that economy. In this scenario, universities, rather than being under threat, will become more central. Far from losing their autonomy, they may conceivably become more powerful. Indeed, students, with their challenges to received ideas and their inspiration of new ones, represent a crucial comparative advantage of universities as economic actors in a knowledge-based society. In comparison to firms and research institutes, the continuous flow of human capital guaranteed by the teaching function of the university contrasts with the relatively static environment of government and company laboratories and gives the university research group an advantage over its rivals.

What are the driving forces – the threats and the opportunities – that are giving rise to these contrasting theses? First let us consider the threats. One is the increasing pressure on universities to meeting societal needs and in many cases more particularly the needs of industry. Some see this as threatening the essential autonomy of the university and of the basic researcher as well as the long-term viability of science (e.g. Ziman, 1991 and 1994; Pelikan, 1992). Others have characterised the situation in terms of a fundamental shift in the knowledge production system from 'Mode 1' to 'Mode 2', with more knowledge being produced 'in the context of application' (Gibbons et al., 1994).

A second threat is seen as coming from a combination of the process of globalisation, the development of new information and communication technologies, and changing demands from students as we move from an elite to a mass higher education system in which students are coming to expect continuous learning over their lifetimes not just for three years or so prior to the start of their careers. As a result of these combined forces, new entrants to the higher education market are appearing. For example, in the Unites States, there are organisations like Phoenix University offering cut-price or 'no frills' degrees. There are also companies who are planning to enter the market, including publishers and software companies intent on offering higher education programmes electronically.

A third threat to the university is a possible weakening of the relationship between research and teaching. As the pressures build up on academics to teach more students, to teach them more efficiently, and to provide them with specific skills required by the economy and society, this may have adverse consequences for research. Conversely, pressures to conduct research (often linked to national priorities, whether economic or social) and to publish (either to enhance one's individual career prospects or because the institution is subject to a research assessment exercise) may result in less emphasis

being given to teaching. We shall return to discuss the close relationship between research and teaching later.

At the same time there are numerous new opportunities for universities to move to a more central position in society. The first is the growing importance of research as the source of new knowledge for the knowledge economy. In an era of globalisation, economic competitiveness depends increasingly on innovation. Innovation in turn often draws, amongst other things, upon technological and scientific knowledge. Universities, as a primary source of new scientific knowledge, therefore have an opportunity to play a more central role in contributing to innovation and hence to competitiveness and economic development.

Secondly, and very much linked to this first point, there is the growing demand from organisations as well as individuals for skills and continuous learning. For example, if companies in industrialised nations are to remain competitive with firms in less developed countries where wage costs are significantly lower, they need to continuously upgrade their knowledge and skills to create higher value-added products. Similar arguments apply to individuals in industrialised nations; those who lack more sophisticated and up-to-date skills will in effect find themselves in competition for jobs with workers paid far lower wages in other parts of the world. In both the organisational and the individual case, the problem is being accentuated by the increasingly rapid obsolescence of knowledge and skills. Hence the growing demands for further expansion of higher education and for 'life-long learning'.

Thirdly, new information and communication technologies could revolutionise the way in which teaching and learning take place. As we shall see below, these technologies offer new and perhaps far more effective means to deliver teaching both within educational institutions and in the form of distance learning. Similarly, such technologies are beginning to transform the process of research and knowledge production in a number of ways. These include a dramatic increase in modelling and simulation to complement traditional experimental approaches, as well as enhancing the ability of researchers to collaborate in larger groups at a distance in more effective ways.

A shift from mode 1 to mode 2?

In an influential analysis of the changing nature of knowledge production in universities and elsewhere, Gibbons et al. (1994) have argued that we are witnessing a shift from Mode 1 to Mode 2. Mode 1 involves new knowledge

being produced primarily within individual disciplines, mainly in universities and other academic institutes. There is little direct connection to societal needs and the results of the research are transferred at the end of the project to users who may or may not take up those results. There is also only fairly limited societal accountability required from those engaged in research in terms of justifying the expenditure of the public funds used to support their work; the obverse of this is that there is a considerable degree of autonomy for those engaged in basic research in universities and academic institutes to choose their own problems on which to work.

Mode 2, by contrast, generally involves multi-disciplinary or trans-disciplinary research carried out in a growing variety of institutions (i.e. not just universities) and with a blurring of the boundaries between the traditional sectors (university, industry etc.). Knowledge is increasingly being produced "in the context of application" – in other words, with societal needs having a direct influence from an early stage and with relatively explicit social accountability for the funding that is received by researchers from government.

In its strongest form, the claim of Gibbons and his co-authors is that

> we are now seeing fundamental changes in the ways in which scientific, social and cultural knowledge is produced. ... [T]his trend marks a distinct shift towards a **new** mode of knowledge production which is replacing or reforming established institutions, disciplines, practices and policies.[1]

The implication here is that Mode 2 is new. However, Gibbons et al. are somewhat less convincing in terms of putting forward systematic evidence for such a new phenomenon (cf. Weingart, 1997; Godin, 1998). As we shall see later, it is perhaps better to characterise this not so much in terms of the appearance of something new in the form of Mode 2, but rather a shift in the balance between the already existing forms of Mode 1 and Mode 2. In other words, there has perhaps been relatively more Mode 2 taking place towards the end of the 20th Century than in previous decades.

However, as some have pointed out (e.g. Pestre, 1997; Weingart, 1997; Shinn, 2000) and as will be argued below, we may be merely returning to a balance between the two modes that was exhibited in earlier eras. Indeed, the origins of modern science in the 17th Century have been found to combine a quest for the solution of practical problems of economic and social import with a desire for understanding for its own sake (e.g. Merton, 1938). The subsequent separation of Mode 1 and Mode 2 may perhaps represent merely an intermediate phase in the development of science, one that is now in the process of being eroded. For example, nano-science and nanotechnology

[1] Quoted on the back cover of Gibbons et al. (1994) – emphasis added.

seem to be following molecular biology and biotechnology in becoming virtually indistinguishable from one another, as motives and outcomes are combined and practitioners of each are increasingly one and the same (National Science and Technology Council, 1999).

The emergence of a triple helix model and of the 'entrepreneurial university'?

An alternative but related characterisation of the changing nature of knowledge production and of universities has been put forward by Etzkowitz and Leydesdorff.[2] They suggest that the increasingly close links between universities, government and industry can be couched in terms of a 'triple helix' model. In this, universities are seen as taking on a new third mission (in addition to the two traditional missions of teaching and research) of contributing to the economy. According to Etzkowitz, the taking up of this third mission represent the 'second academic revolution' (the first having been when primarily teaching institutions took on the role of research – see Jencks and Riesman, 1968). The result is the emergence of the 'entrepreneurial university' which combines teaching, research and contributing to the economy particularly in the local region (Etzkowitz, 1997; Etzkowitz et al., 2000; see also Clark, 1998).

The triple helix is an appealing metaphor. However, questions have been raised as to its validity and what the model adds conceptually (e.g. Shinn, 2000). Furthermore as we shall see later, there must be some doubts as to whether this three-sided relationship and the 'third mission' of the university are entirely new. Indeed, academic entrepreneurship has been identified as an important factor early in the history of the German chemical industry with its close relationship to academic researchers (Gustin, 1975). More important, however, is the current issue of whether a 'third mission' or the entrepreneurial university represents a specialised phenomenon encapsulated in engineering schools and 'land grant' universities in the US and regional colleges in Sweden, such as Karskronna Ronneby, or a general and even predominant academic tendency as represented, for example, by the two Cambridges (in the US and UK) and the Karolinska University as well as their aspirants world-wide (Clark, 1998; Etzkowitz, in press).

[2] See Etzkowitz and Leydesdorff (1997, 1998 and 2000), and Leydesdorff and Etzkowitz (1996 and 1998).

The changing social contract

A third formulation of the changes under way in research and in universities is couched in terms of a changing 'social contract' between science and the university, on the one hand, and society and the state, on the other (e.g. Guston and Keniston, 1994a). The former social contract, which ran from 1945 to the late 1980s (although the exact timing varies somewhat across individual countries), is generally linked to Vannevar Bush and his 1945 report, *Science: The Endless Frontier*. This set out a simple linear 'science-push' model of innovation,[3] beginning with basic research, leading on to applied research, then technological development and finally innovation. The clear implication was that, if government put money into the basic research end of the chain, out from the other end of the chain would eventually come (at some indeterminate time) benefits in terms of wealth, health and national security (although exactly what form those benefits would take was also unpredictable). According to Guston and Kenniston (1994a, p. 2), the social contract for the post-war period could be described in the following terms:

> Government promises to fund the basic science that peer reviewers find most worthy of support, and scientists promise that the research will be performed well and honestly and will provide a steady stream of discoveries that can be translated into new products, medicines, or weapons.

The linear model had the great merit of simplicity (even politicians could understand it!) as well as obvious financial convenience – it furnished a ready case for getting money out of governments. It also implied that few strings should be attached to the research process and to the public funds provided to basic researchers, leaving them and their institutions with considerable autonomy. According to one metaphor, this can be likened to government throwing sacks of money over the wall to the scientists within the university who, at some later stage, may toss back the results of their research, only some of which may subsequently be picked up by firms and other 'users' and exploited to yield economic or social benefits.

Beginning some time around the end of the 1980s (but perhaps slightly earlier in certain countries like the UK and the US), we have seen the emergence of a revised social contract (cf. e.g. Guston, 2000). In the case of the United States, that revised contract was described by Representative George Brown (for many years, a leading Congressional figure in US science policy) as follows:

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3 As Godin (2000, p.5) has noted, this was perhaps the first time that the linear science-push model had been set down formally, although it had appeared in discussions at the end of 19th Century.

> The scientific community must seek to establish a new contract with policy makers based not on demands for autonomy and ever increasing funds, but on the implementation of an explicit research agenda rooted in [social] goals (Brown, 1992, quoted in Guston and Kenniston, 1994, pp. 6-7).

In other words, under the revised social contract there is a clear expectation that, in return for public funds, scientists and universities must address the needs of 'users' in the economy and society. Furthermore, they are subject to much more explicit accountability for the money they receive.[4] In addition, implicit in the new contract is a much more complex model of innovation than the previous linear model, unfortunately making it much harder to persuade politicians of the merits of increasing public spending on research![5]

Analytical questions

These various discussions about the future of knowledge production and the university raise a number of questions which this paper will be try to address.

- Are universities becoming more closely linked to societal needs? Is a new third function emerging? Or are we merely reverting to the situation in an earlier era?
- Is there more Mode 2 research now and, if so, compared with when?
- Is the social contract changing and, if so, compared with when?
- Will the university survive (at least in its current form)? Is the threat from new entrants greater now than in the past?
- Will the university become more central in the knowledge economy? If so, at what cost (if any) to its autonomy?
- How great a threat is the separation of research and teaching? Will the university remain a multi-function institution?

To address these questions, we shall put forward an evolutionary model of the university, examining how it has evolved over time in the light of its

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4 Examples of this greater emphasis on accountability and hence on evaluation include the Research Assessment Exercise (RAE) to which UK university departments have been subject since 1986, and the application of the Government Performance and Results Act (GPRA) to research agencies and programmes in the US.

5 One way perhaps to convince the politicians is to portray the series of organisational innovations, regulations and programmes in the US and elsewhere over the past 30 years as operating somewhat like locks in a canal, transforming the linear model from a presumed automatic process into an assisted flow of innovation, with regular funding increases in health and other research areas of economic and social relevance providing that necessary assistance (Etzkowitz, Gulbrandsen and Levitt, 2000).

changing environment. Such an evolutionary model may then help us assess rather more systematically the prospects for the university in coming years.

HISTORY AND EVOLUTION OF THE UNIVERSITY SPECIES

Evolving functions

Let us go back to the beginning – to the mediaeval university. Originally, this had two functions: teaching priests, public servants, lawyers and so on; and scholarship in a variety of disciplines (biblical, classical, philosophical, medical etc.). Over time as the surrounding societal environment changed, so those two functions evolved. With regard to teaching, there emerged two relatively distinct types of teaching function, one being to develop the full potential of the individual student, the other to produce trained people with the knowledge and skills that were useful for society, be they priests, administrators, physicians or whatever. Scholarship also evolved over time with two fairly fundamental changes. The first was that scholarship was broadened to include the creation of new knowledge – in other words 're-search' – as well as the re-analysis and synthesis of existing knowledge. Secondly, a distinction emerged between two types of research – knowledge 'for its own sake' as opposed to knowledge to meet the needs of society.

Evolving structure, function and external relationships of universities

These changing functions were reflected in the co-evolution of the university and of disciplines. In order to educate undergraduates in a 'discipline', one needed to combine the efforts of a number of academics who grouped themselves into departments, each headed by a 'chair' or professor. As disciplines became more specialised (and too broad for a single professor to cover), new disciplines appeared through a process of sub-division. (Later, new disciplines also began to emerge through the synthesis or fusion of existing disciplines or parts of them.)

As regards the environment in which universities operated, particularly important were the changing relationships (and often tensions) with key external actors. Initially, the relationship of the university with the church was crucial; however, over later centuries, most universities moved to inter or non-denominational status. Also central was the relationship with the monarch or the government, particularly as most universities became part of the public sector (although some in the United States and Japan, for example,

remained outside the government sector). A third external actor is industry. Here, there have been historical phases of closer and then more distant relationships, the former generally occurring when national needs were greatest (in time of war, for instance, or when there was concern about international competitiveness). Other significant relationships that have shaped the evolution of universities are those with other non-university teaching institutions (such as technical colleges) and with 'research only' institutions such as the Max Planck (formerly the Kaiser Wilhelm) institutes in Germany and the CNRS laboratories in France.

Emergence of different 'species' of universities

These changes in the function of the university and in the environment in which it operated were reflected in the emergence of a number of different types or 'species' of university. First, the mediaeval university was gradually transformed over time depending on the national environment in which it existed. For example, in Germany it was transformed into the Humboldt university model, whereas in Britain it became the Cardinal Newman university. The European model was later transferred to other countries, emerging in the United States as the 'Ivy League' university and in Japan as the imperial university (subsequently becoming the national university). Although there are significant national variations between these various national models, they can be treated as a single 'species', henceforth referred to as the 'classical university'.

Later on saw the appearance in Europe of a second species variously termed the technical college (or 'high school' or university), the institute of technology or the polytechnic. Again, this model was later transferred to the United States, Japan and elsewhere. While covering quite a range of variations, these can again be grouped together as a single species which we shall subsequently refer to as the 'technical university'.

Although these have been the two main species of university, other fairly distinct species have emerged at different times. For example, in the second half of the 19th Century a new species was created in the United States – the so called 'land grant' university – which was set up explicitly to meet local or regional needs, initially agricultural but later on industrial needs more generally. Other members of this 'regional university' species include the regional colleges in Europe which are seen as an 'engine' for the development of a

6 Some might dispute whether the land-grant university is really a separate species from the institute of technology. As in the biological kingdom there is an element of ambiguity in such classification decisions.

region, especially the economic and industrial development but perhaps also culturally (for instance, as in Sweden).

In addition, the United States witnessed the creation of various hybrids. For example, Cornell University was set up as a cross between the Ivy League and the land-grant university. It should also be noted that not all universities took on a research function; in several countries, 'teaching only' institutions co-existed with 'full' universities combining teaching with research. Examples of the 'teaching university' species include the grandes écoles in France, the Fachhochschulen in Germany, the former polytechnics in Britain, and the so-called 'liberal arts' colleges (although many of them teach science as well as humanities students) in the United States.

Evolving ethos of the university

Implicit in the two main species of university outlined above are two quite distinct conceptions of the nature and purpose of the university. According to the first, which might be termed the pure or 'immaculate' conception, the purpose of the university is education and knowledge 'for its own sake'. Set against this is the instrumental or utilitarian ethos according to which the role of the university is to create and disseminate useful knowledge and to train students with skills useful to society.

These rival conceptions were perhaps implicit from the start within the mediaeval university (cf. Geuna, 1998). However, over time the tensions between them led to the emergence of two distinct species so that, in a process akin to speciation, we arrived at the classical university and the technical university. In the former, with the Cardinal Newman version one had the 'ivory tower' of independent scholars producing knowledge for its own sake and passing it on to students to enable them to develop their full potential. In the Humboldt version was added the essential integration (or even unity) of teaching and research, along with a heavy dependence on the state for funding. (The notion of 'autonomy' was not as important as it was for 'classical universities' in other countries at the time, nor compared with the prominence it was given in academic ideology after 1945.)

As regards the technical university species, one of the earliest examples was the Ecole Polytechnique set up to provide training for engineers and to meet the military needs of France. Other examples include the technical 'high schools' in Germany and Switzerland, and the institutes of science and technology in Britain at Manchester and Imperial College, London. As

7 S. Hemlin (private communication).

was noted earlier, this species was later transferred to other countries like the Unites States (with the formation of institutes of technology such as MIT and Caltech), Italy (for instance, the polytechnics in Milan and Turin set up to train engineers for companies like Olivetti and Fiat – see Etzkowitz et al., 2000, p.322) and Japan (for example, the Tokyo Institute of Technology which emerged out of an earlier technical school then college).

Co-evolution of different university species

Within each national environmental 'niche', there have normally been two or more species of universities co-existing. In Germany, for example, the Humboldt universities co-existed with the technical universities and the Fachhochschulen. In France, there were the universities and grandes écoles, and in Britain the universities and institutes of science and technology and later the polytechnics. In the United States, there was even more variety with the Ivy League universities, land-grant universities, institutes of technology and 'liberal arts' colleges (teaching-only universities), not to mention hybrids like Cornell. In Japan, three types of university – national, prefectural (i.e. state government) and private – have co-existed.

In each of those countries, there has been continuous tension between the rival ideologies. For example, the tension between the pure and the utilitarian ethos was particularly pronounced in the United States in the latter part of the nineteenth century. Eventually, the pure ethos came to dominate in the early part of the twentieth century, particularly in the prestigious institutions in North America (e.g. Harvard) and in Europe (e.g. Berlin, Oxford, Paris). After 1945, Mode 1 became the more prominent form of knowledge production in such institutions, or at least the one that was accorded most visibility in the prevailing academic ethos.

However, it is important to stress that there was still much Mode 2 knowledge production taking place even during this time. In the United States, for example, over the second half of the 20th Century the great majority of research in universities was funded by the mission-oriented agencies such as the Departments of Defense, Energy and Agriculture, the National Institutes of Health and NASA rather than the basic research agency, the National Science Foundation. This research was closely linked to meeting societal needs in the defence, energy, agriculture, health and space sectors. It was conducted not only in 'technical universities' such as MIT but also in Ivy League and state universities. Nevertheless, in the ideology of academic science that was developed and strengthened during this time, the emphasis was very much on Mode 1 knowledge production – in other words, on the immaculate conception of the university.

RELATIONS AND TENSIONS BETWEEN THE FUNCTIONS OF THE UNIVERSITY

Co-evolution of structure and function

In the past there was a fairly close correspondence between the structure of universities and their functions. As noted earlier, students in order to obtain a full education in a 'discipline' needed to be taught by a group of lecturers and this was best organised in a department. Likewise, research often required some degree of division of labour, collaboration and the sharing of resources such as equipment or a library. Therefore, in the past it was generally effective to organise research within the discipline-based department.

Today, however, there are various tensions that mean that the department may not be the most effective unit. Research is becoming more specialised with the result that it is often organised around subfield-based groups typically of half a dozen or so researchers rather than a discipline-wide department of several times that size (Martin and Skea, 1992; Skea et al., 1992). Those groups will normally need their own specialised equipment rather than sharing it with colleagues in other groups within the same department. In the past, they might have approached departmental colleagues in other subfields for help, say, with theory or methodology. Now however, in an era of easy, cheap, fast communication, instead of wandering down the corridor to seek help from a colleague in another group within the department, the researcher is more likely to telephone or email the expert in their subfield for their particular query, whatever the institution or country in which that person happens to be located (ibid.).

Another tension arises from the fact that some of the most radical scientific advances come from research at the interstices between disciplines. Such research may be impeded by a rigid departmental structure (based on disciplines) at the university. A similar tension may arise in the case of research that is aimed at meeting user needs, whether governmental, industrial or societal. User needs almost inevitably requires inter- or multi-disciplinary research rather than research fitting into a single neat disciplinary 'box'. Moreover, there is a growing tension arising from students seeking a broader range of skills than those found within a single discipline. Hence, there is now a serious question as to whether the department is still the most effective organisational unit for research and teaching within the university.

Teaching-research symbiosis – reality or convenient myth?

For many, an essential feature of the university is the integration of teaching and research. Since the time of Humboldt, it has become conventional wisdom,

even an article of faith, that research and teaching have to take place within the same institution. Yet there is surprisingly little rigorous evidence to support this belief.[8] According to the traditional rationale, there are mutual benefits between teaching and research. On the one side, in order to provide up-to-date teaching, lecturers need to be at the forefront of their research field. On the other, it is argued that teaching keeps lecturers broad in their interests; if they are not teaching, there is a danger that concentration on research may result in them becoming ever more specialised while the broadening influence of teaching may provide a positive stimulus to their research. There is some circumstantial evidence at both the individual and the institutional level to support this conventional justification for having teaching and research combined in one institution. There is also evidence of the dangers of not combining the two – especially from the academy institutes in Eastern Europe where the lack of involvement in teaching may have been one factor (among several) that led to many of them becoming rather stagnant research institutions.

However, there are also prominent counter-examples of leading institutions where research and teaching are not combined. There are many excellent research-only institutes like the Max Planck institutes, CNRS laboratories, MRC laboratories in the UK and the US National Institutes of Health. Likewise, there are some very good teaching-only higher education institutes such as the French grandes écoles (although some of these have developed a research capability in recent years) and the US 'liberal arts' colleges.

Consequently, it is probably more productive to view the combination of teaching and research as a relationship that brings both benefits (in the form of synergy) and costs (if one is devoting time and energy to teaching, there is less of both of these for research, and vice versa) with some tension between them. In some circumstances the benefits may outweigh the costs, but in others they may not. One cannot automatically assume that the benefits of combining teaching and research will always be greater than the costs, as the conventional ideology of academic science would maintain.

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8 For example, the review reported in Johnston et al. (1993) suggests that most of the previous studies on the factors affecting research performance have focused on factors other than the relationship between research and teaching. In their own study, Johnston et al. came to the following conclusion:
> the overall average productivity between disciplines/schools varies surprisingly little between the full-time research (including postgraduate education) environment of the [Institute of Advanced Studies at the Australian National University] and the demands of teaching-and-research within the [Australian] State systems. (Johnston et al., 1993, p.57)

The two traditional functions (teaching and research) versus the 'third mission'

Next, let us consider the relationship between the two traditional functions of the university – teaching and research – and the 'third mission' of contributing to the economy. Here, the conventional academic ideology is that this third function may damage both teaching – through an over-emphasis on short-term specific skill needs as opposed to a broader education – and also research – because of an over-emphasis on short-term applied research to the detriment of long-term basic research.

Again, there is little rigorous systematic evidence for or against this belief. There is certainly some anecdotal evidence to support it but also some running counter to it. For example, in the case of teaching, at French grandes écoles where the teaching is geared to such specific skills as civil engineering or administration, these institutions nevertheless provide a high quality education that remains useful to the students over many years. As regards research, technical universities such as Imperial College, Aachen and Zurich have been engaged for many decades in research that addressed the needs of society but that has not apparently damaged their ability to conduct very high quality basic research. Likewise, leading US universities funded by the Department of Defense and the National Institutes of Health to carry out research aimed at meeting national needs in relation to defence and health have also been responsible for some of the best quality basic research.

Moreover, it is not just in the twentieth century that the third mission of contributing to the economy and society has co-existed within universities with teaching and research. Indeed, in the latter part of the 19th Century, the third function was perhaps even more pronounced than today (Etzkowitz, 1997, pp. 141-43). For example, in German universities (and later at the turn of the century in Japanese universities), engineering departments worked very closely with companies in the mechanical engineering, civil engineering, chemical engineering and, a little later, electrical engineering sector, often effectively acting as the research laboratories for new companies with the results of their research being directly applicable to innovative products. This does not appear to have curtailed their ability to conduct basic research. In Britain and France leading physicists of the period such as Lord Kelvin and Marie Curie spent up to half their time working on industrial problems (cf. Pestre, 1997), again without adversely affecting their basic research. In the United States, in the case of the land-grant universities, the 'social contract' embodied in the 1862 Morill Act involved giving them land in return for supporting the development of agriculture and helping the farmers (Etzkowitz et al., 2000, p. 319); again, this does not seem to have affected their ability to

carry out basic research or to provide high quality teaching. Indeed, many land-grant universities went on to become leading universities of the 20th Century.

In short, for these examples at least, there is no convincing evidence that an emphasis on helping to meet the needs of society and the economy results in adverse long-term consequences for university teaching and research. (Clearly, this is an area where more empirical research and analysis is required.) Again, it is perhaps best to view the combination of teaching and research with addressing economic and societal needs as bringing both benefits and costs. In some circumstances, the benefits may be outweighed by the costs, in others the reverse may be true as the examples listed above suggest. For instance, there may well be differences across fields, resulting in more benefits and hence more emphasis on the external effects of research within the technical and medical sciences than in the natural and social sciences and the humanities.

CURRENT ENVIRONMENT FACING UNIVERSITIES

The driving forces

Around the late 1980s (the exact timing varies across countries), there was a fundamental shift in the balance between the pure and the instrumental view of the university towards the latter. There were various driving forces behind this, some external and others internal. The external drivers included:

- the end of the Cold War, resulting in a greatly reduced need for research in certain physical sciences and engineering fields. Another closely related factor with similar consequences has been a rapidly dwindling enthusiasm for nuclear energy.
- the growing importance of new technologies such as information and communication technologies and biotechnology. Such technologies are heavily dependent on basic research for their development and exploitation. This has given rise to the notion of the knowledge-based economy and subsequently to pressures on the universities to help deliver that knowledge-based economy if nations are to survive and thrive in an increasingly competitive world.
- globalisation and growing competition, with the result that science and technology are now viewed as strategic, competitive resources that nations have to use to maximum advantage. In addition, as part of that globalisation process, higher education is becoming a much more global

9 S. Hemlin (private communication).

'market'. In the past, higher education markets were essentially national, at least at the undergraduate level, but that is currently changing.[10] Universities are also facing new entrants from the industrial sector, with some companies setting up their own universities, such Unipart University and British Aerospace University in the UK.

- constraints on public expenditure, these having been particularly pronounced in European Union countries in the run up to meeting the Maastricht criteria. Those constraints have contributed to the increased demands for public accountability in all areas of government spending, including that on science and the universities. As a result, assessment has become much more common, not least in the UK with both research assessment and teaching quality assessment now playing a key role in university policy.
- firms becoming more reliant on knowledge and skills for their competitiveness – as noted above, some of them are creating their own 'universities' to train and meet that demand because they do not feel that traditional universities are doing this very effectively.
- students demanding not only useful skills but also education in a cheaper and perhaps more convenient form, for example through the Internet.

There have also been various internal drivers shaping the evolution of universities over the last decade. These include:

- the emergence of interdisciplinary research areas giving rise, as mentioned earlier, to tensions within the university structure (is the department still the right organisational unit?) and possibly also weakening the link between research and teaching.
- poor infrastructure – for example, UK universities have suffered from over two decades of a lack of investment in their infrastructure, constraining their ability not only to conduct frontier research but also to train students in state-of-the-art techniques. The result is that some major employers such as the chemical and pharmaceutical companies are concerned that the students they recruit have not been trained on the latest equipment and consequently have to be retrained as soon as they are recruited.
- pressures to do more teaching as a consequence of the higher student/staff ratios linked with the move towards a mass higher education

10 In the past, for example, the great majority of British undergraduate students went to British universities. In the last year, however, the number of British undergraduates registering at universities in the United States reportedly jumped by some 50%, a dramatic change in such a short period of time.

system. There are also pressures to do more research – reinforced in some countries such as the UK by periodic research assessment exercises. These pressures are leading to many staff being stressed or even demotivated.

- relatively low academic salaries in many countries (the United States is perhaps one exception) which have also contributed to the worsening of morale as well as making it extremely difficult to recruit in departments such as computing and management. Similarly, the increasing reliance on short-term contracts for researchers and the consequent sense of uncertainty has aggravated the problem of low morale (e.g. Ziman, 1994).

Impact – the return to an earlier social contract?

These various external and internal driving forces are bringing quite fundamental changes in the perception of the role of the university. Universities are now expected to contribute much more to the development of the critical technologies that nations feel they need to be at the forefront of – the technologies that are often identified in national foresight or other priority-setting exercises (Martin and Irvine, 1989; Martin, 1995; Martin and Johnston, 1999). What we are witnessing here is a significant shift in the social contract; there are now much more explicit and direct expectations that, in return for public funding, universities and researchers should endeavour to deliver greater and more direct benefits to the society than they did in the period from 1945 through to the late 1980s.

As noted at the start, there are some who believe that these changes threaten the autonomy of the university and the basic researcher. However, the historical analysis presented in this paper would suggest that what is involved here is actually more a shift back to the social contract embodied in the nineteenth century in the institutes of technology and technical universities, and in the land-grant universities in the United States. If so, the fact that universities were able to survive and to adapt to the social contract then in place would imply that they can do so again in the early 21st Century.

THE FUTURE – THE END OF THE UNIVERSITY?

One of the questions raised at the start was whether the university is under such severe threat that one must ask whether it has a future. In the light of this brief review of its history, it is clear that the university is a very adaptable organism. Throughout its history, it has proved able to evolve in a changing environment. Indeed, it is so adaptable that there have been very few instances

of the 'death' of a university.[11] Universities reproduce but they very rarely die. (Some might argue that this is a bad thing!)

Given this adaptability, we would expect the university to survive but perhaps to take on new or modified evolutionary forms – new species or hybrids. In short, there will be far greater variety across higher education institutions. First, we will continue to see general universities combining teaching and research. Secondly, there will be new hybrids – perhaps a hybrid of the traditional 'bricks and mortar' university with the open university delivering a large proportion of its higher education at a distance, the so-called 'bricks and clicks' university.[12]

Thirdly, there will be specialised universities, in particular teaching-only institutions although those may be the ones that prove most vulnerable to new entrants from the commercial sector. Research-only universities are also possible – some in the US are now almost research-only institutions. However, the one attempt at a graduate research training only institution in the US in the late 19th century, Clark University, soon retreated and recruited undergraduates to help cover costs as well to generate future income from loyal alumni. Indeed, even as the commitment to research and technology-transfer intensifies, elite US universities such as Chicago and Columbia are also expanding their undergraduate populations and working hard to improve their experience. In short, multiple missions may reinforce, as well as exist in tension with, each other.

Fourthly, there will be new entrants. New private universities are beginning to emerge in Europe particularly in Central and Eastern Europe but also in countries like Germany where nine such institutions are being created (Pearson, 2000). There are also likely to be more 'no frills' universities like Phoenix University, adopting the philosophy of the supermarket to 'pile them high, sell them cheap'. Commercial publishers and software companies are certainly getting involved in 'e-universities', and some consultancies are developing research and teaching capabilities which they may subsequently package and offer to others outside the company. There will probably also be more company universities; already certain large firms in the United States and Britain (e.g. British Aerospace) have decided that the skill and training

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Some might contend that this is where the evolutionary model breaks down because universities do not die. However, there is at least one analogy in the biological world - the subterranean fungi that have apparently survived for thousands of years without dying. Whether this evolutionary tale holds any lessons for universities we leave for others to judge!

One example of this is the University of California, Santa Cruz, which, in addition to 10,000 'traditional' students, has 70,000 obtaining higher education delivered into their homes or offices (M.R.C. Greenwood, presentation at SmithKline Beecham Science Policy Workshop, London, 1997).

needs of their employees are so extensive and perhaps so specific that it is more effective to provide them through their own 'university' rather than using traditional universities.

A fifth possible development is the networked university, either involving vertical integration of further education colleges with a university to form an integrated supply chain or horizontal integration of similar departments across several institutions working together and linked electronically. There may also be closer integration with research institutes like the Fraunhofer institutes and perhaps also the integration of some universities with consultancies to form another possible hybrid.

Sixthly, we shall certainly see the spread of the 'entrepreneurial university' species predicted by Etzkowitz (1997) – that is, institutions giving considerable emphasis to the third function of contributing to the economy as well as to teaching and research. Lastly, there may possibly be more mergers and acquisitions. Already in London, University College, London (UCL) and Imperial College have taken over most of the previously free-standing medical research institutes. Likewise in Sweden, the Karolinska University in Stockholm, as part of a 'network' strategy to enhance its critical mass, has taken over nursing, social work and other professional schools across Sweden.

SOME TENTATIVE CONCLUSIONS

Are universities becoming more closely linked to societal needs? Is a new third function emerging?

Let us now attempt to provide some tentative conclusions to the original questions set out at the start of the paper, the first of which concerns whether universities are becoming more closely linked to societal needs. This analysis has suggested that there has certainly been a shift in the balance compared with the period from 1945 to the late 1980s when the relationship between the teaching and research activities of universities, on the one hand, and the needs of society, on the other, was much weaker. However, even during this period the links with societal needs were not as insubstantial as the dominant academic ideology might suggest. As we have noted, a large proportion of government-funded research in the United States during the post-war period was funded by mission-oriented agencies like the Department of Defense and the National Institutes of Health. Within universities such as MIT and Stanford, much of the research was explicitly trying to address societal needs (cf. Etzkowitz et al., 2000, p.318), even though the rhetoric of that time suggested that autonomy was all important to the university and to scientific research.

Since 1990, however, the situation has become more much similar to that

prevailing in the late nineteenth century, with many universities taking up again the third mission of contributing to technology transfer, innovation, the economy and society more generally. Just as universities survived and indeed thrived under these challenges a century ago, so they are likely to be able to adapt to their new and more central role in the knowledge-based economy and to take advantage of the opportunities that this brings without sacrificing their autonomy (cf. Benner and Sandstrom, 2000; Pearson, 2000).

Is there now more Mode 2 research than previously? Compared with when?

One important characteristic of Mode 2 research is its inter- or trans-disciplinary nature. In relation to this, we need to remember that there have always been interdisciplinary research areas. Science is a dynamic system consisting of both established disciplines and emerging interdisciplinary fields. What starts off as a new multi-disciplinary or inter-disciplinary research area may ultimately over time evolve into a recognised separate discipline. There are numerous historical examples of this, for example experimental psychology emerging from a combination of anatomy and physiology with philosophy, or the formation of biochemistry from biology and chemistry. Cognitive science is a more recent example arising from a combination of several fields including psychology, philosophy, linguistics and computer science to form a new discipline. This continuous creation of new disciplines from interdisciplinary research areas has always been going on.

Likewise, research that is carried out 'in the context of application' (a second key characteristic of Mode 2 research) has always been present within universities, in particular in universities in Germany and the United States at the end of the 19th century. Similarly, there has always been some blurring of institutional boundaries, a third Mode 2 characteristic. The US land-grant university was set up to provide an agricultural extension service to farmers as well as to carry out the traditional tasks of teaching and later research. As noted earlier, such blurring of institutional boundaries may be more common or more pronounced in the case of technical and medical sciences than in the natural sciences.

Nevertheless, during the 20th Century and particularly after 1945, Mode 1 came to be seen in academic ideology as the 'normal' form of knowledge production while Mode 2 was viewed as a less central or even 'deviant' form of research that posed mortal dangers to the university as an institution. That period is now ending. Yet, while there is probably more Mode 2 research today than during the period from 1945 to the late 1980s, the level is not necessarily greater than a century earlier.

Is the social contract changing? Compared with when?

As with the previous question, the answer would appear to be, 'Yes, but only compared with the period from 1945 to the late 1980s'. This then raises the question of whether that post-war period was merely a temporary and, in historical terms, comparatively brief phase. One possible interpretation, for example, is that the relative generosity of the state towards science and the willingness to provide funds to researchers without too many strings being attached represented a reward to scientists for their perceived contributions in helping to wage and to win the Second World War – for instance, though their research on the atom bomb, radar, penicillin, operations research and code breaking.

However, there are almost certainly other historical factors at work. In particular, during the 20th Century, the assumption that the public and private spheres were separate was at its height. That assumption is now being displaced by a model of overlapping spheres (cf. Etzkowitz et al., 2000), with several activities which in the 20th century were viewed as solely government responsibilities now being organised on a joint public-private (or even a private) basis. In the case of science and of universities, this trend is reflected in the growing importance of patents (part public, part private), incubators for start-up firms, university 'spin-offs' and so on (ibid.).

Etzkowitz and Leydesdorff (2000, p. 110) have described the transition for science and universities as one from 'endless frontier' to 'endless transition'. University research is becoming closer to application and the remaining steps are easily bridged by such mechanisms as patents and start-up firms, whereas in the previous phase one needed formal technology-transfer mechanisms which were premised upon distinct boundaries between university and industry.

Will the university survive (in its current form)?
Is the threat from new entrants greater now?

As has been argued above, the university has proved remarkably adaptable over the course of its long history. The environment in which it has operated has been in constant flux. There have always been new entrants – former technical colleges, further education colleges, more recently the Open University and other distance-learning institutions. However, universities have always managed to adapt to the changing environment and to the new competition, perhaps by shifting the emphasis between their functions, perhaps by embracing new functions, occasionally even forming a new species. One new factor, however, is the development of information and

communication technologies. These may substantially lower the barriers to entry facing new entrants to the higher education sector (as they threaten to do in many other sectors). This may lead to more new species and hybrids, as we noted earlier, and to more blurring of institutional boundaries. However, it is unlikely to threaten the survival of the university (cf. Barnett, 2000).

Will the university become more central in the knowledge society? At what cost to its autonomy?

The analysis presented here suggests that the university will become more central as the economy and society become more reliant on knowledge. It will be responsible for generating not only intellectual but also economic and social capital. As we have seen in recent decades, many of the most successful innovative regions in North America and Europe have included entrepreneurial universities as an essential component (Pearson, 2000, pp. 9-10). In coming decades, the university is likely to become an ever more important ingredient in building the knowledge-based economy.

Will this come at the price of reduced autonomy? Benner and Sandstrom (2000) have considered this from the perspective of neo-institutionalist theory. They describe and contrast the two models by which university research has previously been funded. The 'autonomy model' is exemplified by the traditional research council emphasising scientific quality, an international orientation and academic initiatives, reinforced by collegial reputational control and an orientation towards basic research. In contrast, in the 'interventionist model', the mission-oriented agency is at the centre, trying to re-orient academic research to industry's knowledge interests, with the funding agency acting as a pro-active entrepreneur.

Benner and Sandstrom (ibid., p. 300) suggest that we are witnessing the emergence of a new organisational field that is a hybrid of traditional academic research and the knowledge-based economy, combining collegial recognition with entrepreneurialism and societal accountability. This 'trans-institutional model' has been emerging since the 1980s, combining elements of the above two models in a organisational form related to the triple helix of Etzkowitz and Leydesdorff. The new model is based on academic autonomy and initiatives taken by university researchers, but at the same time efforts are made to direct academics to modes of operation that address the needs of industry (ibid.).

> The main difference from the interventionist model is the catalytic rather than the regulating role of the funding agency. The intention is to develop transinstitutional norms for knowledge production, which evolve within

> a wide socio-economic network, involving academic and industrial interests in the regulation of research programs. (ibid., p. 300)

As a consequence, the autonomy of the university may actually be strengthened as it becomes less dependent on government funding. The ability to establish more explicit policies than previously may increase with the result that there may be less accidental evolution than in the past. Indeed, the university may be undergoing an historic shift from an eleemosynary institution, virtually wholly dependent upon other institutional spheres for support, to at least a partially self-sustaining institution, based on earnings from patent royalties and equity holdings in companies formed from academic research. Such a possibility may seem relatively slim at present. Even after 20 years of effort at technology transfer, there are few institutions such as MIT that receive as much as one quarter of their research funding from industry, or like Columbia that earn $100 million per annum or one tenth of their budget from patent income. Nevertheless, the trend toward the capitalisation of academic knowledge is growing, especially as the recognition of a clear relationship between a university's research income and its production of commercialisable knowledge becomes more widely recognised.

How great a threat is the separation of research and teaching? Will the university remain a multi-function institution?

As we have seen, there has always been a degree of separation between teaching and research in some academic institutions. Consequently, to argue that such a separation represents 'the end of civilisation as we know it', as some academics have implied, is to exaggerate the dangers. Most universities may remain multi-functional but certainly not all of them.[13] Some may choose to focus primarily on undergraduate education (as many have done during the 20th Century or earlier), some largely on research and graduate education. Others may embrace the third function and become entrepreneurial universities. One contributing factor here is likely to be the decreasing time lag between the creation and use of knowledge. This may encourage the convergence of certain 'classical' and 'technical' universities, swelling the population of the 'entrepreneurial university' species in which are combined the functions of knowledge creation, knowledge transfer (particularly through trained students) and knowledge exploitation – i.e. the integration of the three functions of teaching, research and contributing to the economy.

13 See the earlier discussion of Clark University and its attempt to separate research from undergraduate teaching.

To sum up, the university will, over coming decades, inhabit a fast-moving and complex environment. Political and economic circumstances will be constantly changing. New technologies will offer universities and other institutions innovative ways of offering higher education and of doing research. Competition among universities and with other institutions will become more fierce and more global. New competitors will appear. In this environment, the rate of evolutionary change on the part of universities will almost certainly be more rapid than in earlier centuries. Existing university species will continue to adapt. New hybrids (such as the 'clicks and bricks' university) and new species of universities (for example, the networked university) will emerge. At the institutional level, there will be mergers and acquisitions, and perhaps even the occasional 'death'. But the university will survive.

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