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WHAT IS CHANGING IN ACADEMIC RESEARCH? TRENDS AND FUTURES SCENARIOS

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What is changing in academic research? What has changed over the past decades and what might change in the coming ones? Could the research mission of universities be carried out in slightly or radically different ways in the medium term? This paper aims to cast light on the trends and driving forces that can be observed in academic research over the past two decades in the OECD area[1]. It gives an outlook of the main current characteristics of academic research at a macro level in terms of funding and activities in comparison with research performed by other sectors. It also highlights future challenges and sketches a few possible futures scenarios for academic research in a 20 year time frame.

In this paper, academic research is understood as research and development (R&D) undertaken in the higher education sector, including universities, polytechnics, etc., and research centres that have close links with higher education institutions[2]. The trend analysis mainly draws on quantitative data from the OECD R&D and Main Science and Technology Indicators (MSTI) databases, including unpublished data, from the latest edition of the US National Science Board (NSB) on *Science and Engineering Indicators* (NSB, 2004) and from the OECD Education database. All unreferenced data come from the OECD databases.

Before focusing on academic research, one should bear in mind a few facts about and trends in the overall R&D efforts of OECD countries.

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[1] As of 2006, the Organisation for Economic Co-operation and Development (OECD) has 30 member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

[2] This is the definition adopted by the Frascati Manuel (OECD, 2002). Higher education includes: "all universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status; all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions." Public research organisations with strong links with universities–such as the CNRS (National Centre for Scientific Research) in France—are thus included, while academies of science are not. For student enrolments data, higher education refers to general and vocational tertiary education, that is levels 5a, 5b and 6 of the International Standard Classification of Education (ISCED).

First, R&D has grown significantly during the two past decades within the OECD area, which accounted for about 80% of all R&D expenditures in the world (OECD, 2005a). Gross domestic expenditure on R&D amounted on average to 2.3% of GDP (Gross Domestic Product) in 2003, against 1.9% in 1981. In real terms (that is, controlling for inflation[3]), R&D expenditures have more than doubled between 1981 and 2003.

Second, with some variations across countries, the business sector carries out and funds the bulk of R&D in the OECD area[4]. In 2003, Greece, Poland, Portugal and Turkey were the only countries reporting more R&D expenditures in the higher education than in the business sector. The prominence of the business sector has sharpened over the past decades. Between 1981 and 2003, the share of R&D performed by the business sector has risen from 65.4% to 67.7% of the total R&D effort in the OECD area. Business expenditures on the performance of R&D have risen from 1.26 to 1.53% of GDP, that is by 141% in real terms. The business enterprise sector has also increased its financing of R&D from 1 to 1.39% of GDP between 1981 and 2003. This increasing performance and funding of R&D by businesses is one of the most significant trends of the past decades – explaining to some extent why OECD economies are often described as increasingly knowledge-based economies (Foray, 2004; Boyer, 2002).

Finally, another major trend lies in the relative decline of government as a performing sector and as a funding source of R&D. The share of R&D performed by the government sector (e.g. military research, agronomy, academies of science, ministries, etc.) has (almost continuously) decreased from 17.9% to 12.3% between 1981 and 2003 in the OECD area. In the same time period, the government-funded R&D decreased from 0.85% to 0.68% of GDP, and the percentage of total R&D financed by government, from 40% to 30.4%. This funding decline is relative though: in real terms, government expenditures have actually increased by 60% since 1981. The share of government military R&D has decreased significantly between 1986 and 2001 (from 43 to 28%), but has increased again after the events of 11 September 2001 and amounted to 33% of government R&D spending in 2004[5].

The remainder of the paper will focus on academic research, where parallel trends can be observed[6]. The first section documents the growth in funding and output. The second section shows that academic research can be characterised by its large proportion of basic research and government funding, although the mode of allocation of public funding has changed in the past twenty years (section 3). A noteworthy trend has been the rise of the private funding of higher education and performance of basic research by the non-academic sectors (section 4). Internationalisation of academic research has grown significantly (section 5), while a new attitude of civil society towards research (section 6) and new computing and networking opportunities offered by information and communication technology (ICT) are emerging as new driving forces for the future of academic research (section 7). The last section brings all these trends together by proposing four futures scenarios for discussion (section 8).

1. The massification of academic research

Following general trends in R&D, except for government research, higher education research has gained ground during the past twenty years. Between 1981 and 2003, the share of R&D performed by the higher education sector has increased from 14.5% to 17.4% of the total R&D effort within the OECD area

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[3] Throughout the paper, "real term" comparisons are based on deflated data expressed in constant prices (US dollars of 2000) and power purchasing parities (PPP).

[4] The performance of R&D by each sector is measured by their share of gross domestic expenditures on R&D. Another indicator lies in their respective research personnel.

[5] The patterns of military R&D vary significantly in the European Union and the United States. The share of military research has indeed decreased and levelled off in the European Union since 2001: military R&D accounted for 15% of government R&D expenditures in 2004, against 56% in the United States.

[6] More on general trends in R&D can be found in OECD (2005a).

(Table 1). While higher education's share of R&D remains much smaller than within the business sector, the former has increased more quickly. Expenditures on R&D in the higher education sector amounted to 0.39% of GDP in 2003 in the OECD area, against 0.28% in 1981. This increase represents almost a three-fold increase in R&D expenditures in real terms during this time period (while R&D expenditures in businesses "only" doubled).

Two other pieces of evidence of this massive increase of academic research lie in the number of higher education researchers and the output of scientific articles.

Between 1981 and 1999, the number of higher education researchers has increased by 127% (full time equivalent) – that is by 7% a year on average. Although this increase reflects a general growth of R&D personnel in the OECD area (research personnel in the business sector has grown by 118% in the same period), the percentage of higher education researchers has slightly increased and amounted to 26% of all researchers in the OECD area in 2003, up from 24% in 1981 (and from 22% in 1985). Here again, variations across countries are significant: while this share is low in the United States (14.8%) and weights much in the aggregated mean, higher education researchers represented on average 40% of all researchers in an OECD country in 2003 (and 35% at the EU-15 aggregated level).

The growth of the research output is another major trend in academic research during the past two decades. It is highly correlated with (and probably well explained by) the growth of R&D expenditures and of researchers in the higher education sector. About 650 000 new scientific articles have been published in 2001, a 39% increase compared to the 466 000 published in 1988 (NSB, 2004)[7]. About 82% of them were produced by OECD countries. Most of these articles result from research carried out in the academic sector. In the United States, the higher education sector authored 74% of all the US scientific articles in 2001. The share is probably higher in other countries where the non-academic sector is smaller. Similarly, the number of new academic books published has increased – and probably the number of books published by academics. For example, books published by US university presses have increased by 21% between 1993 and 2004; and academics have probably been responsible for a larger amount of the 74% increase in books published in the United States over the same period (www.bookwire.com).

Measured by their article output in 2001[8], clinical medicine (31% of all scientific articles within the OECD area), biomedical research (15%), physics (12%), chemistry (10%), and other "hard" sciences and engineering represented the bulk of academic research – social sciences, psychology, health sciences and professional fields accounting for about 10% of the OECD article output. The relative shares of these fields in the total scientific literature have remained fairly stable since 1988. This does not take into account humanities, whose share of academic R&D expenditures was on average about 9% in the 15 countries for which information is available, ranging from 1 to 19%. The share of expenditures between different fields, including humanities this time, has remained fairly stable since 1981 in OECD countries, natural sciences and engineering accounting on average for about 75% of the total R&D expenditures in the higher education sector – that is somewhat less than their share of the scientific literature.

An interesting and puzzling recent trend is the flattening of the scientific article output of the United States since 1992, and of Canada, the United Kingdom and the Netherlands from the late 1990s, although real expenditures and the number of researchers continued to grow (NSB, 2004). The reasons are unknown and are under investigation. They might relate to the age structure of the research workforce (does a researcher produce less when close to retirement?), a change in professional practices (for example a

[7] These figures exclude the output in humanities, but include social sciences and psychology.

[8] This measure should be taken with caution as the typical number of articles published varies significantly across disciplines: a researcher in clinical medicine will typically publish 10 articles a year, against 1 for a researcher in engineering (European Commission, 2003). In the United States, data are available on the academic R&D expenditures by field: they match the ranking according to article output (NSB, 2004).

Table 1: Gross Domestic Expenditure on R&D (GERD) performed by sector, 1981, 2003 (%)

		Business Enterprise	Government	Higher Education	Private Non-Profit
Australia	1981	25.02	45.11	28.55	1.32
	2002	51.17	19.33	26.70	2.80
Austria	1981	55.85	9.03	32.80	2.33
	2002	66.84	5.69	27.03	0.45
Canada	1981	48.11	24.42	26.66	0.82
	2003	52.99	10.99	35.72	0.29
Czech Republic	1981	..	..	..	..
	2003	60.99	23.34	15.26	0.41
Denmark	1981	49.70	22.67	26.74	0.88
	2003	69.75	6.81	22.77	0.67
European Union	1981	62.03	18.80	17.81	1.36
	2003	64.08	12.74	21.95	1.22
Finland	1981	54.66	22.55	22.24	0.56
	2003	70.49	9.69	19.21	0.60
France	1981	58.92	23.59	16.42	1.07
	2003	62.62	16.68	19.36	1.34
Germany	1981	68.97	13.44	17.06	0.53
	2003	69.73	13.40	16.87	..
Greece	1981	22.46	63.08	14.46	x
	2003	69.73	20.87	48.05	0.96
Hungary	1981	..	..	..	..
	2003	36.73	31.34	26.72	..
Iceland	1981	9.61	60.74	25.97	3.68
	2003	51.76	24.80	21.30	2.14
Ireland	1981	43.58	39.31	16.03	1.08
	2003	66.91	7.92	25.16	..
Italy	1981	56.37	25.72	17.91	x
	2002	48.33	17.57	32.82	1.27
Japan	1981	65.96	12.02	17.56	4.46
	2003	74.98	9.31	13.66	2.05
Korea	1981	..	..	..	..
	2003	76.09	12.59	10.14	1.18
Netherlands	1981	53.26	20.77	23.18	2.78
	2002	56.65	13.79	28.83	0.72
Norway	1981	52.87	17.65	28.95	0.52
	2003	57.45	15.10	27.45	..
Poland	1981	..	..	..	..
	2003	27.42	40.67	31.72	0.20
Russian Federation	1981	..	..	..	..
	2003	68.44	25.28	6.06	0.22
Slovak Republic	1981	..	..	..	..
	2003	55.20	31.61	13.16	0.03
Slovenia	1981	..	..	..	..
	2003	58.85	15.99	15.99	2.37
Spain	1981	45.49	31.57	22.95	x
	2003	54.10	15.36	30.34	0.19
Sweden	1981	63.65	6.09	29.99	0.26
	2003	74.10	3.48	22.03	0.39
Switzerland	1981	74.20	5.92	19.88	x
	2000	73.91	1.31	22.86	1.92
Turkey	1981	..	..	..	..
	2002	28.70	7.01	64.29	..
United Kingdom	1981	62.96	20.64	13.55	2.85
	2003	65.73	9.66	21.39	3.21
United States	1981	69.31	18.50	9.74	2.45
	2003	69.76	12.39	13.74	4.11
Total OECD	1981	**65.4**	**17.9**	**14.5**	**2.3**
	2003	**67.7**	**12.3**	**17.4**	**2.6**

Source : OECD R&D database

change of attitude towards the widespread practice of slicing research outputs in minimal publishable pieces), or merely a statistical artefact.

The massification of higher education has been an important driver of this growth. Enrolments and participation rates in higher education have increased dramatically since the Second World War, and higher education systems have adjusted by creating new institutions and hiring new staff who generally teach and carry out research. For example, in the United States enrolments in higher education have almost doubled from 8.5 million students to 16 million between 1970 and 2001; in Japan they increased by 85%; in France they doubled (according to their national statistics)**.** Between 1985 and 2003, the number of higher education students enrolled (full time) within the OECD area has increased by 80%, from about 20 to 36 million students – that is a pace of 4% a year on average[9]. As a result of this growth, the academic workforce has risen, and given that academics typically teach and carry out research, albeit to a greater or lesser extent according to their status, so have the research workforce (full time equivalent) and research output. However, it is noteworthy that in the United States (the only country for which this piece of information is available), the recent growth of the academic workforce has concerned academics whose primary activity has been research rather than teaching – which may be one reason for the more rapid growth of research personnel compared to the student population.

Other drivers of this growth lay in the "professionalisation" of the academic profession (including specialisation and standardisation of the trade), the importance of the quantitative research output in academic career paths and the emergence of strong external incentives to publish following the introduction of research assessment exercises in several countries. The well-known "publish or perish" rule is actually rather recent. By comparison, a very influential and respected scholar like Ludwig Wittgenstein has published two books in his life time. While the quantity of scientific literature has increased, we have no information about the evolution of its quality over time[10].

Whether this growth of academic research will continue in the future depends on at least two factors, assuming that the massification of higher education and the emergence of a "knowledge economy" (and thus the growing importance granted to research) have really been the main drivers of this growth. The massification of higher education has reached its peak in many OECD countries: participation rates are above 45% in 15 OECD countries, which have more or less reached universal higher education; between 35 and 45% in 7 others, which can still increase their participation; and below 35% in only 4 countries. Enrolments have been flat for years in many OECD countries, and countries like Japan and Korea are actually already facing a slight decline in enrolments. Given that the corresponding cohorts of young people are sometimes declining, the massification will continue in some countries, like Mexico and Turkey, and might continue in others as educational policy goals often include increasing participation rates; however, the room for growth is more limited than it has been in the past. In this context, massification might become less of a driver of growth for academic research. The drive of the knowledge economy will probably continue. But given that growth in the knowledge economy relies on innovation and R&D in general, and not necessarily on R&D carried out in the higher education sector, academic research will probably be under pressure to demonstrate its value added compared to other sectors in order to continue growing.

[9] OECD Education database. My estimate for 1985.

[10] Indicators like the "relative citation index" can be seen as an approximation of the quality of countries' research output (see section 7), but they would just allow one to rank countries' output, not the overall quality of research. And international rankings are relative and thus do not say anything about the evolution of research quality over time.

2. Basic research: the main mission of academic research?

What is special about academic research then? Basic research is clearly part of the answer. In 2003, basic research accounted for about 18% of the gross domestic expenditures on R&D in the OECD area, up from 15% in 1981. The higher education sector represents less than one fifth of all R&D expenditures in the OECD area, but it carries out the bulk of basic research in most OECD countries. In 2003, an OECD country had on average 54% of its basic research performed in the higher education sector. And the government and higher education sectors accounted together for 82% of the whole basic research (Table 2).

In 2003, the higher education sector devoted about 64% of its R&D activities (expenditures) on basic research in the OECD area, against 5% for businesses, 29% for government, and 46% for the private non-profit sector. Korea is the sole country where the business sector consistently spends more on basic research than any other sector (including the higher education sector), probably because of the weight of the business enterprise sector (it spends only 11% of its budget on basic research, but this amounts to 80% of the higher education's R&D budget). In Eastern Europe (Czech Republic, Hungary, Poland, Slovak republic), the government sector undertakes more basic research than the higher education sector – although decreasingly so. Before the 1990s, Eastern European countries followed the Soviet tripartite model according to which universities focused on teaching, Academies of science conducted basic research, and Academies and Ministries, applied research (Geuna and Martin, 2003): the distribution of national basic research between the higher education and government sectors still reflects this history (path dependency).

How has this distribution of basic research between sectors evolved over the past 20 years? The average shares of national basic research performed by the higher education and government sectors in the OECD country for which data are available for both 1981 and 2003 have decreased from 64 to 59%, and from 24 to 18%, respectively. And conversely, the shares of the national basic research performed in the business enterprise and private non-profit sectors have increased, from 10 to 19%, and 2 to 6%, respectively (Table 2). Should these growths continue at the same pace in the future, government and higher education would carry out about 60% of a country's basic research on average in 2025.

While the relative share of academia in overall basic research expenditures has decreased, the higher education sector is the only sector mainly devoted to basic research. At the OECD aggregated level, the percentage of basic research performed in total R&D has increased between 1981 and 2003 within all performing sectors; by 19% in the private non-profit sector, whose share of basic research expenditures were just below 50% in 2003; by 8% in the higher education and in the government sectors; and by 1% only in businesses (Table 3). The capitalisation of the business sector explains that a seemingly insignificant growth has significant effects in the distribution of knowledge between sectors. The business enterprise sector actually spends only 5% of its R&D expenditures on basic research, which remains a marginal activity in its R&D. At country level, the average share of basic research undertaken in the higher education sector slightly declined from 55 to 53%, while it followed the trends of the OECD aggregated level in the other sectors. This can be explained by the significant growth of academic basic research in the United States, which has offset the decline of the share of basic research performed by academia in smaller countries like Iceland or Australia.

In conclusion, basic research does indeed represent a special feature of academic research. But this might become decreasingly the case because of the rise of basic research within the private non-profit sector and, to a lesser extent, the government sector. A possible response would be for academic research to specialise even more in basic research to keep its specificity (or competitive advantage), as it has been the case from the 1990s in the United States. As we will see below, other forces might push academic research in other directions. It is noteworthy that this specialisation is partly beyond its control: should the business sector decide to carry out more basic research than it does, it would rapidly increase its share of the total basic research carried out on average in OECD countries. But this does not seem very likely for

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Table 2: Distribution of domestic basic research expenditures across sectors (%)

	Higher Education			Government			Business Enterprise			Private Non-Profit		
	1981	1992	2003	1981	1992	2003	1981	1992	2003	1981	1992	2003
Australia	55	59	56[3]	40	28	24[3]	3	9	14[3]	2	4	7[3]
Austria	..	..	76[3]	..	..	7[3]	..	..	17[3]	..	..	0[3]
Czech Republic	..	21[8]	31	..	75[8]	63	..	4[8]	6	..	..	0
Denmark	78[1]	74	74[10]	19	22	7[10]	2	3	17[10]	..	..	2
France	..	65	69	..	19	15	..	13	13	..	3	2
Germany	59	56[2]	..	22	25[2]	..	18	19[2]	..	..	..	..
Hungary	..	37	39	..	56	57	..	7	3	1	..	..
Iceland	62	57	57	33	35	32	0	8	0	4	..	10
Ireland	65	64	61	20	5	9	15	30	30	1	1	..
Italy	63	55	..	30	38	..	7	7	..	..	..	..
Japan	59	47	40	12	10	22	26	37	35	3	5	3
Korea	..	31[5]	25	..	21[5]	19	..	45[5]	56	..	2[5]	0
Mexico	..	64[6]	49[4]	..	..	46[4]	..	3[6]	5[4]	..	0	0
New Zealand	..	..	54	..	33[6]	39	..		7	..	..	..
Norway	79	80	74	15	14	15	6	6	11	1	..	..
Poland	..	36[7]	47	..	54[7]	47	..	10[7]	6	..	0[7]	0
Portugal	..	78	73	..	7	5	..	1	3	..	15	20
Slovak Republic	..	16[7]	28	..	66[7]	58	..	17[7]	14	..	..	0
Spain	50	70	59	37	17	13	12	13	28	..	1	0
Sweden	90	92	..	4	3	..	7	5	..	0	0	..
United Kingdom	..	..	..	..	..	..	..	..	..	..	..	..
United States	49	47	55	29	21	19	15	24	16	7	8	11
Comparable mean	64	64	59	24	20	18	10	15	19	2	3	6
Country mean (for each year)	64	55	54	24	29	28	10	14	16	2	4	4

Source: *OECD R&D database*

Notes: 1: 1982 instead of 1981; 2: 1991 instead of 1992; 3: 2002 instead of 2003; 4: 2001 instead of 2003; 5: 1996 instead of 1992; 6: 1993 instead of 1992; 7: 1994 instead of 1992; 8: 1995 instead of 1992; 10: Discontinuity with precedent years

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Table 3: Basic research as a percentage of R&D performed by each sector (%)

	Higher Education			Government			Business Enterprise			Private Non-Profit		
	1981	1992	2003	1981	1992	2003	1981	1992	2003	1981	1992	2003
Australia	67	64	52[12]	31	28	30[12]	5	6	7[12]	53	79	59[12]
Austria	48[1]	48[6]	49[12]	25[1]	21[6]	22[12]	6[1]	4[6]	4[12]	27[1]	28[6]	18[12]
Czech Republic	..	41[7]	..	..	48[7]	..	..	1[7]		..	3[10]	..
Denmark	60[2]	60	55	17[2]	22	17	..	..	5	55[2]	56	57
France	89[3]	89	86	1[25]	19	22	3	4	5	48[3]	40	45
Germany	78	73[8]	..	38	39[8]	..	6	6[8]	4	22	31[11]	..
Hungary	33[4]	44	45	34[4]	55	57	2[4]	5	3	..	..	..
Iceland	70	47	44	15	20	21	1	..	0	33	49	79
Ireland	46	33	48	5	4	23	5	6	9	6	8	..
Italy	52	52	..	25	36	38[12]	2	3	5[12]	..	..	49[12]
Japan	30	33	37	13	16	30	5	7	6	9	15	17
Korea	..	..	36	..	..	22	..	..	11	..	..	3
Mexico	..	34[6]	53[13]	..	24[6]	41[13]	..	8[6]	8[13]	..	14[6]	33[13]
New Zealand	..	..	64	..	..	45	..	..	5	..	..	..
Norway	48	48[6]	49	14	12[6]	17	2	2[6]	3	16	..	..
Poland	..	50[9]	60	..	50[9]	43	..	8[9]	8	..	33[9]	45
Portugal	54[2]	43	47	10[2]	7	7	1[3]	1	3	35[2]	26	45
Slovak Republic	..	84[9]	83	..	40[9]	67	..	8[9]	9	..	..	0
Spain	50	51	48	21	18	21	5	5	12	12[3]	31	42
Sweden	70	67[8]	..	15	13[8]	80[13]	3	2[8]	..	0	38[8]	..
United Kingdom	..	..	..	..	16[6]	34	..	5[6]	5	..	..	..
United States	67	67	75	21	24	29	3	6	4	38	47	52
Total OECD	57	66	64	21	24	29	4	6	5	27	47	46
Comparable mean	55	52	53	19	21	30	3	4	5	31	38	46
Country mean (for each year)	58	54	55	20	26	33	3	5	6	27	33	39

Source: OECD R&D database

Notes: "Total OECD" corresponds to the weighted mean; the "country mean" says; for each year; what is on average the percentage in an OECD country; Iceland and the United States having the same weight; "comparable mean" is a country mean that is comparable over time (i.e. calculated for countries available for all years). 1: 1985 instead of 1981; 2: 1982 instead of 1981; 3: 1986 instead of 1981; 4: 1987 instead of 1981; 5: 1983 instead of 1981; 6: 1993 instead of 1992; 7: 1995 instead of 1992; 8: 1991 instead of 1992; 9: 1994 instead of 1992; 10: 1996 instead of 1992; 11: 1989 instead of 1992; 12: 2002 instead of 2003; 13: 2001 instead of 2003.

the near future: the low propensity for the business sector to carry out basic research shows that there is still a strong case for continued research in the public and non-profit sectors.

3. Academic research and new public management

Research performed by the higher education sector is largely government-funded in the OECD area (Table 4). In 2003, the government sector funded directly or indirectly 72% of the total academic research. Governments fund academic research through "general university funds", that is block grants directly given to higher education institutions (and then allocated by them to research and teaching), as well as through direct research grants and contracts given to particular academic research projects. In 2003, government funding amounted to more than 80% of academic research in 16 out of the 28 OECD countries for which information is available. The share of the government funding tends to be lower in countries with large private higher education sectors (as universities have then more private resources), where the level of tuition fees or private endowments is high, and where there is a tradition (or friendly fiscal policy) for donations and foundations. With 51% of government-funded academic research in 2003, Japan was by far the country with the lowest governmental-funded academic research in the OECD area. Probably due to the large size of its private component, the Japanese higher education sector funded on its own funds 46% of the country's academic research.

While the prevalence of public funding remains a major characteristic of academic research, a significant trend lies in the growing use of competitive or quasi-market forces for the allocation of this funding, both at governmental and institutional levels.

One hard piece of evidence of this shift lies in the evolution of the distribution of public funding for academic research between general university funds and grants awarded to separately budgeted research projects (Table 5). Between 1981 and 2003, the percentage of research funding through general university funds has dropped from 78% to 65% in the 16 OECD countries for which information is available for both years. While general university funds still funded over 70% of academic research in 2003 in 8 OECD countries, they have decreased by more than 13% in New Zealand, Ireland, the United Kingdom, Australia, Finland, Denmark, Greece, Spain and Turkey. Moreover, the allocation of these general university funds have been increasingly (partially) performance-related in many countries, generally based on university research evaluation that were introduced in several countries in the late 1980s and 1990s (Geuna and Martin, 2003).

General university funds give universities (and other higher education institutions carrying out research) full freedom to allocate these funds within their institution[11]. However, the management of these funds within universities has also become increasingly competitive and based on departmental research evaluation (Hazelkorn, 2005). Direct government funding to separately budgeted research projects gives governments more control to choose the type of research they want to support. It is generally awarded by research councils following a competitive process: either a tender or following a competitive application process generally based on peer review.

This reflects recent trends in public management and in the governance of higher education institutions (OECD, 2003a), using to a greater extent than in the past competition and quasi-market forces to foster efficiency and accountability. In a context of mass tertiary education and ageing society, the best

[11] In some countries, academic research is not financed through general university funds. For example, in the United States, general university funds are conceptually considered as exclusively devoted to instruction. Although these funds probably support some departmental research at US public universities, the corresponding data are generally not collected (and would only appear as funds spent by the universities themselves).

Table 4: Funding Sources of Higher Education R&D (%)

	Government			Business Enterprise			Higher Education			Private Non-Profit			Funds from Abroad		
	1981	1992	2003	1981	1992	2003	1981	1992	2003	1981	1992	2003	1981	1992	2003
Australia	95	93	89[7]	1	2	5[7]	3	4	3[7]	0	..	0[7]	1	1	3[7]
Austria	98	97[4]	91[7]	1	2[4]	4[7]	0	0[4]	1[7]	..	..	..	0	0[4]	4[7]
Belgium	86[1]	71[4]	69[8]	9[1]	12[4]	13[8]	0[1]	1[4]	1[8]	3[1]	7[4]	11[8]	2[1]	8[4]	7[8]
Canada	79	71	63	4	8	9	7	6	8	10	15	19	1	1	1
Czech Republic	..	97	93	..	..	1	..	..	0	..	..	3	..	..	3
Denmark	96	88	84	1	2	3	2	5	8	..	..	..	1	5	6
Finland	95	88[4]	83	2	5[4]	6	2	2[4]	2	0	4[4]	1	1	2[4]	8
France	98	93	90	1	4	3	0	0	0	1	2	4	0	1	2
Germany	98	92	85	2	8	13	..	..	..	x	x	x	..	1	2
Greece	100	59[4]	65	0	4[4]	8	0	0[4]	1	0	6[4]	5	0	31[4]	21
Hungary	64[2]	83	85	36[2]	11	11	..	..	1	..	..	..	0[2]	2	4
Iceland	79	91	78	1	5	9	0	0	3	8		0	12	4	10
Ireland	83	67	82	7	7	3	3	2	2	0	4	5	7	20	9
Italy	96	93	..	3	5	..	..	..	..	0	..	..	1	2	..
Japan	61	52	51	1	4	3	0	0	1	37	44	46	0	0	0
Korea	..	44[5]	71	..	22[5]	14	..	2[5]	2	..	32[5]	13	..	0	0
Luxembourg	..	..	100	..	..	..	..	..	..	..	..	..	..	..	..
Mexico	..	..	68[8]	..	..	1[8]	..	..	0[8]	..	..	29[8]	..	..	2[8]
Netherlands	97	96	87	0	1	7	2	2	2	0	0	..	0	0	4
New Zealand	..	66	64	..	4	4	..	6	5	..	20	25	..	4	2
Norway	94	89[4]	87	3	6[4]	5	2	3[4]	3	1	1[4]	2	0	1[4]	3
Poland	..	81[6]	83	..	11[6]	6	..	1[6]	0	..	6[6]	6	..	1[6]	4
Portugal	94[3]	80	90	0[3]	0	2	3[3]	1	2	2[3]	2	3	2[3]	17	4
Slovak Republic	..	99	93	..	1	0	..	..	0	..	..	3	..	..	4
Spain	100	89	70	0	7	6	0	0	1	x	x	18	0	3	5
Sweden	93	84[4]	71	2	5[4]	5	4	7[4]	16	1	2[4]	2	1	2[4]	6
Switzerland	90	92	82[7]	10	2	6[7]	..	3	3[7]	..	4	9[7]	..	..	..
Turkey	..	83	68[7]	..	15	22[7]	..	3	10[7]	..	..	..	..	..	0[7]
United Kingdom	81	70	65	3	8	6	5	12	17	9	5	4	2	6	8
United States	74	67	68	4	7	5	7	7	7	15	18	19	..	..	..
Total OECD	**81**	**74**	**72**	**3**	**6**	**6**	**3**	**4**	**5**	**13**	**14**	**16**	**..**	**..**	**..**
Comparable mean	87	82	79	4	5	6	2	3	4	5	8	9	2	6	6
Country mean (for each year)	89	81	78	4	6	6	2	3	4	5	10	10	2	5	5

Source: OECD R&D database

Notes: Korea: Excluding R&D in the social sciences and humanities; United States: Excludes most or all of capital expenditure. 1: 1983 instead of 1981; 2: 1987 instead of 1981; 3: 1982 instead of 1981; 4: 1993 instead of 1992; 5: 1995 instead of 1992; 6: 1994 instead of 1992; 7: 2002 instead of 1993; 8: 2001 instead of 2003.

way to fund and deliver both research and teaching components of higher education is under debate in many OECD countries. Concerning levels as well as sources of funding, the debates include consideration of, among other factors, national budgetary priorities and the desire to increase the resources available; questions about the efficiency of resource use; ensuring that public policy objectives (e.g. high-quality education and research) are met; and determining what government should provide and how costs should be shared among different groups in society (taxpayers, students and families, companies). Moreover, there is a strong social demand for better public management. Accountability, transparency, efficiency and effectiveness, responsiveness and forward vision are now considered the principal components of good public governance, which universities are being (and will most likely) increasingly be asked to implement (Braun & Merrien, 1999). The shift towards more autonomy and entrepreneurship is a common trend in higher education management in most OECD countries (Etzkowitz et al, 2000; Marginson & Considine, 2000; Martin, 2002; OECD, 2003a).

Table 5: Percentage of government funding of academic research, by mode of funding (%)

	Direct Government			General University Funds		
	1981	1992	2003	1981	1992	2003
Australia	11	..	33[7]	89	..	67[7]
Austria	..	15[4]	19[7]	..	85[4]	81[7]
Belgium	46[1]	..	..	54[1]	..	..
Canada	51	46	57	49	54	43
Czech Republic	..	100	..	..	..	..
Denmark	11	24	31	89	76	69
Finland	14	37[4]	46	86	63[4]	54
France	46	51	35	54	49	65
Germany	..	..	28	..	..	72
Greece	10	27[4]	27	90	73[4]	73
Hungary	100[2]	..	100	..	..	..
Iceland	..	95	22	..	5	78
Ireland	18	41	51	82	59	49
Italy	..	..	..	..	..	..
Japan	39	28	22	61	72	78
Korea	..	..	..	..	..	..
Luxembourg	..	..	100	..	..	..
Mexico	..	..	29[8]	..	100[9]	71[8]
Netherlands	6	5	14	94	95	86
New Zealand	..	21	58	..	79	42
Norway	16	25[4]	26	84	75[4]	74
Poland	..	100[6]	100	..	0[6]	0
Portugal	..	..	..	..	..	..
Slovak Republic	..	..	..	..	..	..
Spain	13	23	31	87	77	69
Sweden	26	35[4]	36	74	65[4]	64
Switzerland	..	19[#]	20[7, 9]	..	81	80[7]
Turkey	..	46	58[7]	..	54	42[7]
United Kingdom	19	35	43	81	65	57
United States	100	100	100	..	..	..
Comparable mean	27	31	39	78	69	65
Country mean (for each year)	28	41	43	77	65	63

Source: OECD R&D database m: Missing information

Notes: United States: Excludes most or all capital expenditure. 1: 1983 instead of 1981; 2: 1987 instead of 1981; 3: 1982 instead of 1981; 4: 1993 instead of 1992; 5: 1995 instead of 1992; 6: 1994 instead of 1992; 7: 2002 instead of 1993; 8: 2001 instead of 2003; 9: Federal or central government only.

One of the interesting effects of these new practices is the creation of a more concentrated academic research. This challenges the Humboldtian idea and the academic professional ethos according to which teaching and research should go together in higher education. In practice, as research funding becomes more concentrated in a few institutions, the ability of some higher education institutions and academics to carry out research becomes more limited (Enders and Musselin, 2006). Some countries already have differentiated types of academic research. In France, some academics employed by the National Centre for Scientific Research (CNRS) are full researchers – while being considered part of the higher education sector. In many Eastern European countries, academies of science (government sector) carry out much more research than university academics, who carry out mainly applied research. But even when such a dichotomy does not exist, the allocation of research funding can differentiate institutions and academics. In the United Kingdom, 9 universities representing 12% of all institutions and 17% of post-graduate enrolments received 47% of the public funding for research in 2002; and the top 4 universities received 29% of this funding (after HESA and HEfCE data). In the United States, academic R&D has been historically concentrated in few of the 3 600 US higher education institutions: in 2001, the top 200 universities accounted for about 96% of all R&D expenditures. The top 100 institutions received 51% of the total public funding for academic research (federal plus local/state); and the top 20, about 20% (according to OECD and NSB data).

The possible future disconnection of academic research and teaching in higher education has already started. Will countries where research is spread relatively evenly across the whole system take a more concentrated approach in the future? This is to some extent where recent trends in public management seem to lead: academic research might just become concentrated in a relatively small share of the system while the largest number of institutions will carry out only little research, if any.

4. The rise of private funding

In spite of government's prominence in the funding of academic research, higher education research has increasingly relied on private sources of financing during the two past decades. Between 1981and 2003, the percentage of government-funded academic research has decreased by 10%, from 81.4% to 71.6%. In 1981, only Japan, the United States (and probably Korea) had less than 79% of government-funded academic research; in 2003, it was the case for twelve OECD countries. Meanwhile, the share of the business sector in the financing of higher education research has doubled to reach 6% in 2003; similarly, the share of the private non-profit sector nearly doubled to 5%; and higher education institutions have also funded a larger share of their research activities on their own funds (Table 4).

The first private source of funding of academic research lies in the higher education sector's own private funds. These "internal" expenditures for academic research have increased 6-fold in real terms between 1981 and 2003, and accounted for 16% of academic research funding in 2003, up from 13% in 1981. This increase cannot be downplayed as a mere adjustment for a decrease of governmental funding given that governmental funding has actually also risen in real terms. It can rather be explained by the expansion of the private higher education sector, the increase of tuition fees in many countries, by new entrepreneurial activities of higher education institutions, like commercial cross-border higher education or commercial courses for adult learners, commercial e-learning, etc. (Ruch, 2001 ; Larsen and Vincent-Lancrin, 2002; OECD, 2004a; OBHE, 2004; Newman and al., 2004). Higher education institutions have had more private resources that they could invest in their academic research, although variations across OECD countries are significant.

On the research side, the growth of academic patenting and licensing highlights the growing "commercialisation" of higher education. In the United States, the Bayh-Dole act of 1980 allowed universities to retain title to inventions resulting from federally supported R&D, giving an incentive to universities to patent and license such inventions. From the mid-1990s, following the US example, a number of OECD countries have tried to encourage the commercialisation of technology developed at academic research institutions by granting the ownership of intellectual property rights to universities and public research organisations (OECD, 2003b). Independently of these policy efforts, new opportunities in the bio-medical fields have been a strong driver of increased patenting (Geuna and Nesta, 2003).

The United States is the country where this trend is best documented. The number of patents received by US universities has increased significantly over the past 30 years from about 250-350 patents in the 1970s to more than 3200 patents in 2001. About 39% of all US academic patents belonged to technology areas with biomedical relevance in 2001 (against less than 25% in the early 1980s). During this time period, the number of institutions awarded patents in a year has more than doubled to reach 190 institutions in 2001. The top 25 recipients received more than half of all academic patents. Revenues from these intellectual property rights have increased sharply during the past decades and amounted to more than 870 million US dollars (NSB, 2004). That being said, the income generated by licenses represents less than 4% of overall academic research expenditures in the United States, where this type of income is the highest within the OECD area, and much less of the overall higher education expenditures. In 2005 the Massachusetts Institute of Technology *alone*, that is the top patenting private US university, had operating revenues of USD 2030 million and spent 997 million US dollars on sponsored research.

This trend can be observed in other OECD countries as well. In 2000, the number of patents granted to universities amounted to 219 in Australia, 394 in the Netherlands; and in 2001, to 404 in Korea and 914 in Switzerland. And the university licenses have generated a gross income of 80 million US dollars in Australia, 1 million US dollars in Korea, and 3 million euros in Switzerland. Here again, this is modest compared of the overall budgets for research and higher education in these countries.

Although the financing of academic research by businesses remains small in absolute terms and amounted to more than 10% of the funding of academic research in only five countries for which information is available (Turkey, Korea, Germany, Belgium and Hungary), its growth highlights increasing links between business and higher education research. In the United States, the share of the business sector's cross-sectoral (co-authored) articles with higher education has increased from 80 to 83% between 1988 and 2001, showing a privileged relationship of businesses with the academic sector compared to others; and the share of the higher education sector's cross-sectoral articles with the business sector has also increased, from 21 to 26% (NSB, 2004). This growing collaboration might reflect the willingness of many countries to see higher education institutions play a role in regional development and participate in regional and national innovation systems, following success stories like the Silicon Valley (OECD, 2001; Storper and Salais, 1997). This might also come from the willingness of the academic sector to value its applied research and its experimental development (that is the 45% of expenditures not spent on basic research at country level). Probably because its research activities are closer to academic research, the higher education sectors collaborates more with the private non-profit sector than with the business sector: collaborations with the non-profit sector amounted to 34% of its cross-sectoral output (NSB, 2004).

To sum up, the rise of private funding in academic research still rests less on funding from the private sector than on the private resources earned by higher education themselves. While government funding has continued to increase in real terms and remains prominent, other sources of funding have increased more rapidly and led to a more diversified system. Should these trends continue in the future, mainly thanks to the higher education and non-profit sectors, one can imagine academic research half privately and publicly funded in the OECD area: this balanced funding would represent a gradual evolution of academic research and of higher education systems towards a more private system, most likely within a non-profit framework.

5. The internationalisation of academic research

Reflecting the internationalisation of higher education (OECD, 2004a; Larsen and al., 2005), and, more generally, the globalisation of economies and societies, academic research has become more internationalised in many respects over the two past decades. International academic mobility, international collaboration, international influence of science, and funding from abroad have all increased, while new poles of research are gradually emerging in the world. Finally, international competition and international rankings set a new context for countries and institutions.

The growing international mobility of academics and of doctoral students highlights the internationalisation of academic research. Flows of academics into the United States increased by 49% between 1994 and 2005, to reach about 90 000 persons in 2005 (IIE, 2005). While there is no systematic evidence for other countries, the intra-European mobility of academics under the Socrates programme of the European Commission grew by 71% between 1997 and 2000, to reach some 12 000 persons in 2000 (OECD, 2004a). In Korea and Japan, while the number of foreign scholars is still small, it has increased significantly over the past decade – by 66% between 1993 and 2003 in Japan, and over 3-fold in Korea between 1990 and 2003 (according to official national statistics). The same pattern can be observed for doctoral and postdoctoral students (OECD, 2005a). In the United States, 41% of all “postdocs” holding a US doctoral degree are foreign-born. And the share of foreign academics (holding a US doctorate) has increased from 12 to 21% of the overall US academic employment—and is much higher in some fields (NSB, 2004). Some emerging countries, like Malaysia, are trying to build capacity in higher education by attracting foreign research institutions and by moving away from the import of foreign educational programmes through franchising. This growing cross-border mobility of academic researchers shows the internationalisation of the academic workforce and research, partly driven by an increasing competition between countries to attract foreign talents in their country (OECD, 2004a, 2005b, 2006; Tremblay, 2004).

Partly related to this mobility[12], international collaboration has grown significantly in academic research. This is reflected in the growth of internationally co-authored (or collaborative) scientific articles, that is articles with at least one international co-author (in terms of institutional affiliation). Between 1988 and 2001, the total number of international articles more than doubled, increasing from 8 to 18% of all scientific articles (Figure 1). In the United States, the share of internationally co-authored articles in the total article output has more than doubled between 1988 and 2001, and amounted on average to 23.2%. In Western Europe, international collaborative articles accounted for 33% of all articles in 2001, up from 17 percent in 1988 – the collaboration having a strong intra-regional component. In Asia, the percentage of international articles also increased from 11% of all articles in 1988 to 21% in 2001. Moreover, the breadth of countries with which each country collaborates for scientific research has increased. Between 1994 and 2001, all countries (for which information is available) have raised the number of countries with which they have jointly authored articles: for an OECD country, the average number of collaborating countries in scientific activities has risen from 89 to 102 countries between 1994 and 2001. But this trend goes beyond the OECD area: emerging and developing countries have actually expanded more the number of countries they collaborate with than developed countries (NSB, 2004) (Table 6). Finally, foreign scientific articles are increasingly cited in the scientific literature worldwide: in 1992, foreign articles accounted for 55% of all citations, against 62% in 2001 (NSB, 2004).

[12] The US National Science Foundations notes a moderately high correlation between the number of US PhDs awarded by country to foreign-born students in 1992-96 and the volume of papers co-authored by the United States and those countries in 1997-2001 (NSB, 2004).

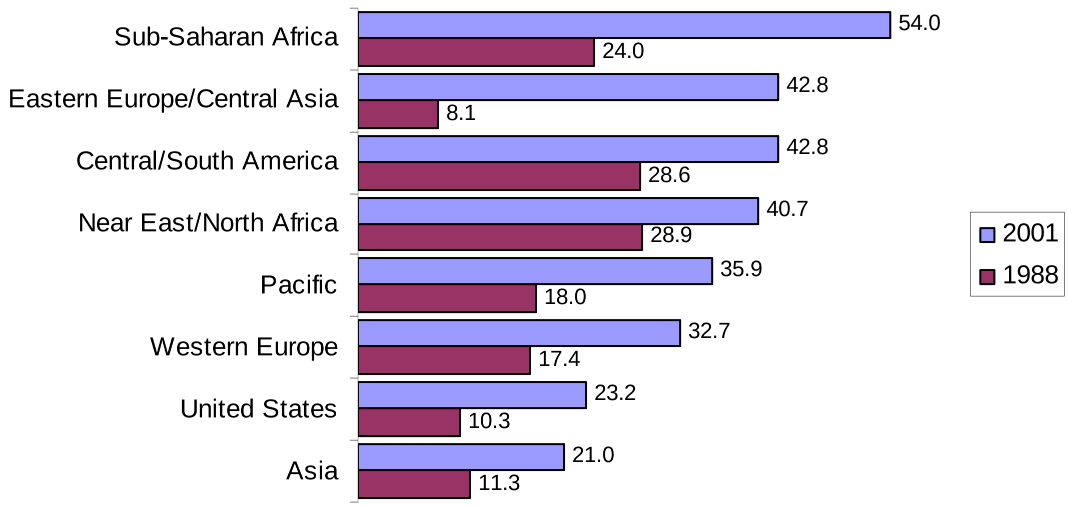
Table 6: Breadth of international scientific collaboration, by country/economy: 1994 and 2001

Country/economy	Collaborating countries	
	1994	2001
Developed		
United States	154	166
France	140	152
United Kingdom	143	150
Germany	125	130
Netherlands	115	127
Italy	114	121
Canada	119	120
Spain	88	116
Switzerland	112	116
Japan	97	114
Belgium	100	112
Australia	93	106
Sweden	110	102
Denmark	83	100
Austria	73	93
Norway	64	87
Israel	71	86
Portugal	51	86
Greece	68	82
Finland	73	81
Ireland	57	71
New Zealand	55	66
Emerging/developing		
China	78	103
Brazil	85	102
India	90	101
South Africa	58	95
Mexico	69	89
Russia	89	88
Poland	73	79
South Korea	52	78
Argentina	58	76
Hungary	64	74
Czech Republic	65	72
Kenya	50	69
Thailand	59	69
Egypt	72	67
Taiwan	46	66
Chile	57	64
Indonesia	37	60
Singapore	36	57
Slovakia	51	54
Nigeria	59	52
Croatia	44	52
Pakistan	37	52
Estonia	29	47
Lebanon	19	46
Philippines	38	46
Vietnam	25	46
Uganda	31	44
Iran	20	44

Source : NSB, 2004

Note: Data are number of countries that have jointly authored articles (based on institutional address) with indicated countries. They are based on data from the Institute for Scientific Information, Science Citation Index and Social Sciences Citation Index; CHI Research, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations

Figure 1: Percentage of international collaborative scientific articles, by region (1988, 2001)



Source: NSB, 2004

Note: The data correspond to the number of articles with at least one foreign coauthor as a share of the total number of articles from the region or country. Article volume is in whole counts, where each institutional coauthor is credited with a whole count. Data come from the Institute for Scientific Information, Science Citation Index and Social Sciences Citation Index; CHI Research, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations

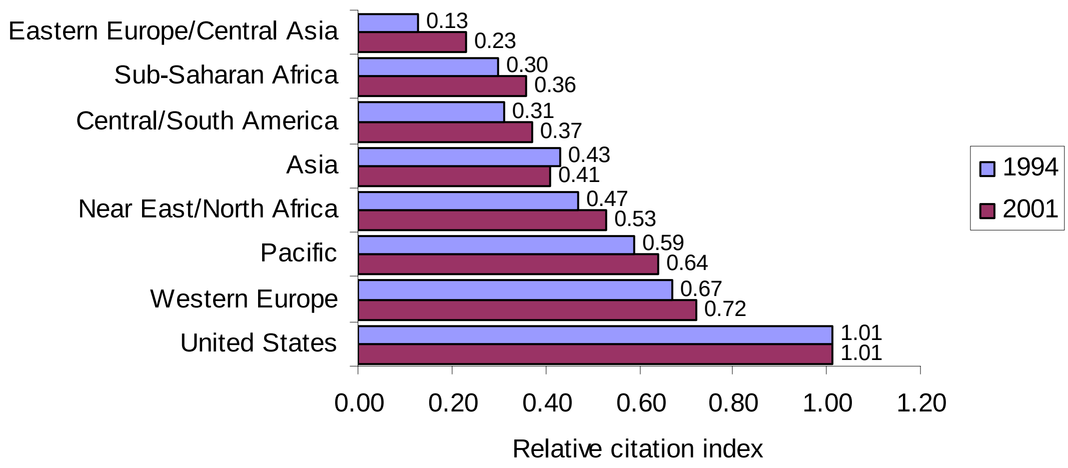
The internationalisation of academic research does indeed correspond to the emergence of new poles of science in the world. Non-OECD countries (for which there is information) have accounted for a larger share of total R&D expenditures over the past decades, China alone representing half of the R&D expenditures of non-OECD countries (OECD, 2005a). Citation of foreign scientific articles provides an index of accessibility, of visibility and of perceived influence and productivity of scientific literature across borders, and also, if one takes into account the practice of courtesy citations, a measure of the insertion of a country's researchers in international networks of scientists and academics. The number of cited articles is highly correlated with the country's output of scientific articles (and financial input in research). The OECD area produced 82% of the world output of scientific literature and accounted for 94% of citations in the world scientific literature, while emerging and developing countries were cited 25 to 75 percent less than their share of scientific literature. The United States produced 32% of the world output of scientific articles in 2001, and its scientific literature accounted for 44% of citations in the world scientific literature[13]. However, other countries and regions are becoming important poles of science and have expanded their scientific output and their worldwide visibility or "relative prominence"[14] more than the United States over the last decade. While North America – thanks to the United States – is clearly the world pole of scientific research, Western Europe took over its output of scientific literature in 1999. Since 1988, most other world regions' output has grown much quicker than the US – albeit from lower starting points. Between 1988 and 2001, the scientific article output has risen by 13% in North America, against 59% in Western Europe, 119% in Asia, 177% in South and Central America, 49% in the Near East and North Africa, 47% in the Pacific – Eastern Europe and Sub-Saharan Africa having experienced a decline of their output of about 20% during the same period. While the relative citation index of the United States

[13] Relative to its population, the United States ranks 12th in terms of article production: see indicator A.14 in OECD (2005a).

[14] One calculates a "relative citation index" for a country or a region by adjusting the frequency of citation of its scientific literature for its world share of scientific articles (NSF, 2005).

(and North America) remained stable between 1992 and 2001, it increased in all world regions but Asia (possibly because of the sharp increase in its output) (Figure 2).

Figure 2: Relative prominence of citations of scientific literature, by region: 1994 and 2001



Source: NSB, 2004

Note: The relative citation index is the frequency of citation of a country or region's scientific literature outside of its own region, adjusted for its world share of Science & Engineering articles. The data come from the Institute for Scientific Information, Science Citation Index and Social Sciences Citation Index; CHI Research, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

The growing international nature of research can also be observed through the rise of foreign funding of R&D. Data are rather patchy for the early 1980s. However, the fact that data have become more systematically collected is in itself a piece of evidence of the increasing importance of funding coming from abroad for the performance of academic research. On average, in the 18 countries for which data are available for both years, the share of funding coming from abroad for the performance of academic research has tripled over the past two decades, representing 6% in 2003 versus 2% in 1981 (Table 4). This can partly be traced back to the strategies and policies of several countries to promote and fund international collaboration in science. The European Union has funded ambitious programmes geared towards intra-European collaborative research, such as its "6th Framework programme". In the United States, federal agencies such as the National Science Foundation, the US Department of Energy (DOE), and the National Institutes of Health (NIH), have (or had) programmes helping fund internationally collaborative research.

The inclusion of R&D in the General Agreement on Trade in Services (GATS) in the World Trade Organisation (WTO) as part of the business services sector[15] might also represent a future transformative force for a further internationalisation of academic research, should it become more privatised. While the inclusion of education services under the GATS has received much attention (OECD, 2004a and b; Larsen and Vincent-Lancrin, 2002; Knight, 2002, 2003), the inclusion of research services in the GATS has been relatively unnoticed, although research represents a significant part of academic activities. While they still

[15] In the GATS services sectoral classification list, "research and development services" are included in the business services, with three sub-categories: R&D services on natural sciences; R&D services on social sciences and humanities; interdisciplinary R&D services.

have to be analysed, the issues are probably similar to those for education services, albeit to some extent easier as they do not involve the same quality issues.

Finally, regardless of the GATS, the growing importance of worldwide or international rankings of higher education institutions, generally according to research criteria, changes the scope of the competition between higher education institutions. Two examples are the worldwide rankings of the Shangai Jiaotong University and of the Times Higher Education Supplement (Altbach, 2006). These rankings are setting an international competition between countries and institutions for attracting international scholars and students and for receiving international funding, which is becoming more available. One of its policy implications, related to the movements of concentration described in section 3, lies in the political willingness to create "world class" research universities in several countries, from China through to Scandinavian countries such as Denmark.

All this emphasises the double nature of internationalisation in higher education, leading at the same time to more collaboration *and* more competition between countries and higher education institutions (Huismans and van der Wende, 2004, 2005). Unless a war, return to nationalism or international pandemy stops it, the internationalisation of higher education and of academic research is likely to continue in the foreseeable future, with more international collaboration, mobility and worldwide competition for internationally available funding. With the emergence of new poles of science, might governments and businesses be tempted to outsource their basic research in countries where labour costs for research are lower? A stronger worldwide division of labour according to specialties and competitive advantages may then appear.

6. A new social contract for research

Higher education institutions have not only become more accountable to governments concerning the efficient and effective use of their research funding, as evoked in section 3, they have also become more accountable to society at large. As Callon (2003) has emphasised, the rise in the number of "socio-technical controversies" on issues regarding the environment (global warming, pollution), health (therapeutic cloning, AIDS, muscular distrophy), food (bovine spongiform encephalopathy, genetically modified organisms), or the patentability of genetic materials represent evidence of a change in the social contract between research and society. Discussion of research is no longer confined to scientists and policy makers: "concerned groups" (or "lay people") have become much more involved in the design, implementation and constructive critique of research, when not in research itself.

Even though they might always have had an influence, concerned groups (patients, families of patients, etc.) were generally not acknowledged as legitimate in positing research problems or making decisions about them. The first power lay with the scientists, while the second was delegated to policy-makers. While this is still to some extent the case, for understandable reasons, concerned people have increasingly managed over the past decades to raise research questions, to voice critiques about the research outcomes or methodology, to challenge research protocols on ethical grounds, to contribute to research by providing researchers with evidence from their personal experience, etc. Callon (2003) gives several examples from different countries. Several studies have been published about the involvement of patients' associations in France in clinical research, from muscular dystrophy to AIDS or to cancer (Callon et al., 2001; Rabeharisoa and Callon, 1999, 2002).

There are several ways to influence or to be involved in research. One way consists in hiring experts or researchers to challenge and monitor the "official" outcomes. Another lies in funding academic research. Part of the increasing share of research funding from the private non-profit sector described in section 4 highlights this trend. In France, a survey on the funding of research by patients' associations estimated that their research funding amounted to 36% of all research funding from charitable and philanthropic association or foundations. This funding obviously gives them some control and decision power about the undertaken research, and forces academic researchers and policy makers to be more transparent in their research and scientific policy decisions.

Hippel (2005) shows that this opening to society cannot only be observed in academic research but also in innovation more generally: innovation is no longer supply-driven but increasingly user-centred. End users are increasingly involved in innovation and contribute to the design and improvement of many, if not most, new industrial and consumer products, according to their actual needs (rather than what manufacturers believe their needs are). For example, the industrial boards and equipment used for windsurfing incorporate user-developed innovations designed by the pioneers of windsurfing for the high-performance sport. Many other examples can be found in software development or in innovation more generally (Lundvall, 1988).

The reasons for this opening of science to public society can be traced back to many factors. The increasing educational attainment of the population in all OECD countries may have led to a blurring of the boundaries between the so-called experts and the lay people, facilitating the emergence of “lay experts”. The emergence of a new history, sociology and philosophy of science challenging the ivory tower model of science may have contributed to a better acknowledgement of the role of concerned groups, as well as the rise of new forms of political activism in the 1960s. But given that these concerned groups generally build themselves by creating a community of people with the same experience or needs, which previously went unnoticed because they were scattered, the easy access to information thanks to information and communication technologies, from radio, TV, Internet and instant messaging, have allowed them to reach a critical mass more rapidly and to more easily share their information and experience.

This involvement of concerned groups and civil society in science and technology issues, including academic research, might continue to grow and reshape social and governmental demands towards science. Callon (2003) proposes to institutionalise the role of civil society by facilitating the explicit recognition of new concerned groups as well as by encouraging, developing and funding more collaborative research involving these groups. Even without public action, one can imagine that these groups will increasingly voice their concerns, participate in research and be recognised. This might be one aspect of a “knowledge society”.

7. Technology

Information and communication technology (ICT) also represents a driver of change in academic research. Because ICT has not revolutionised university teaching and access as quickly as was too optimistically expected in the early 2000s, its past influence and future promises now tend to be downplayed. ICT has not yet revolutionised teaching and learning and represents in most cases an add-on to traditional face-to-face teaching rather than a substitute or a catalyst for new pedagogies. This is partly due to the immaturity of e-learning tools but also to the cultural resistance of students and academics to use existing tools, because of some scepticism about its quality (OECD, 2005c). However, ICT continues to gain ground in higher education and has already enhanced the on-campus student experience, through student portals, the use of the Internet, digital libraries, etc. (Larsen and Vincent-Lancrin, 2006).

ICT has arguably already had a much stronger impact on academic research. It has significantly contributed to some of the trends identified in the above sections: internationalisation, growth (and possibly quality) of the research output, and opening to civil society. Internationalisation of research has been facilitated by cyberinfrastructure, which allows researchers to collaborate and share ideas and expertise across the world without travel, through e-mails. The growth of research output can also partly be derived from the easier and quicker access to information, to digital datasets and to recent research that are often online and remotely accessible (digital libraries, etc.). Similarly, the emergence of concerned groups relies on a critical mass of isolated individuals sharing the same needs or experience. Their emergence has been facilitated by the Internet; and their influence of research, by the easier access to information allowed by digital libraries and other knowledge repositories.

Computers, digital data, and networks have indeed revolutionised the research environment (as much as society at large). As Atkins et al. (2003) put it, “new technology-mediated, distributed work environments are emerging to relax constraints of distance and time. These new research environments are linking together research teams, digital data and information libraries, high-performance computational services, scientific instruments, and arrays of sensors.” This new distributed environment has been referred to as “cyberinfrastructure” (Atkins et al., 2003; Atkins, 2005).

In some fields, ways of researching have been transformed dramatically by ICT thanks to rapid acceleration of computer and network performance, which have allowed researchers to simulate, model and visualise more complex systems and to democratise advance computing. Atkins et al. (2003) give examples in all fields of science and engineering. Interestingly, the digitisation of data also enables more interdisciplinary work, and sometimes the emergence of new fields, thanks to the reuse of data sets in unexpected ways or the linking of several data sets.

The exponential growth of computing and storage capacity will continue in the foreseeable future and many experiments that are still impossible because they would involve too massive data collection and computation will soon become possible, for example in sky modelling (astronomy) or climate modelling (atmospheric science). While high end technologies could be seen as widening the digital divide between the poor and the rich, the lead universities and the others, it is now possible to share (sometimes expensive) research instruments remotely and to have more academics and students participating in cutting edge research, thanks to simulation and visualisation techniques. While issues of intellectual property rights can somewhat hinder collaboration and open repositories of knowledge, this is a growing phenomenon. One aspect of revolutionising cyberinfrastructure lies in the democratisation of research and research instruments and tools, allowing less endowed researchers to follow and contribute to their field more than they could in the past, if not to the same extent as leading researchers.

8. Scenarios

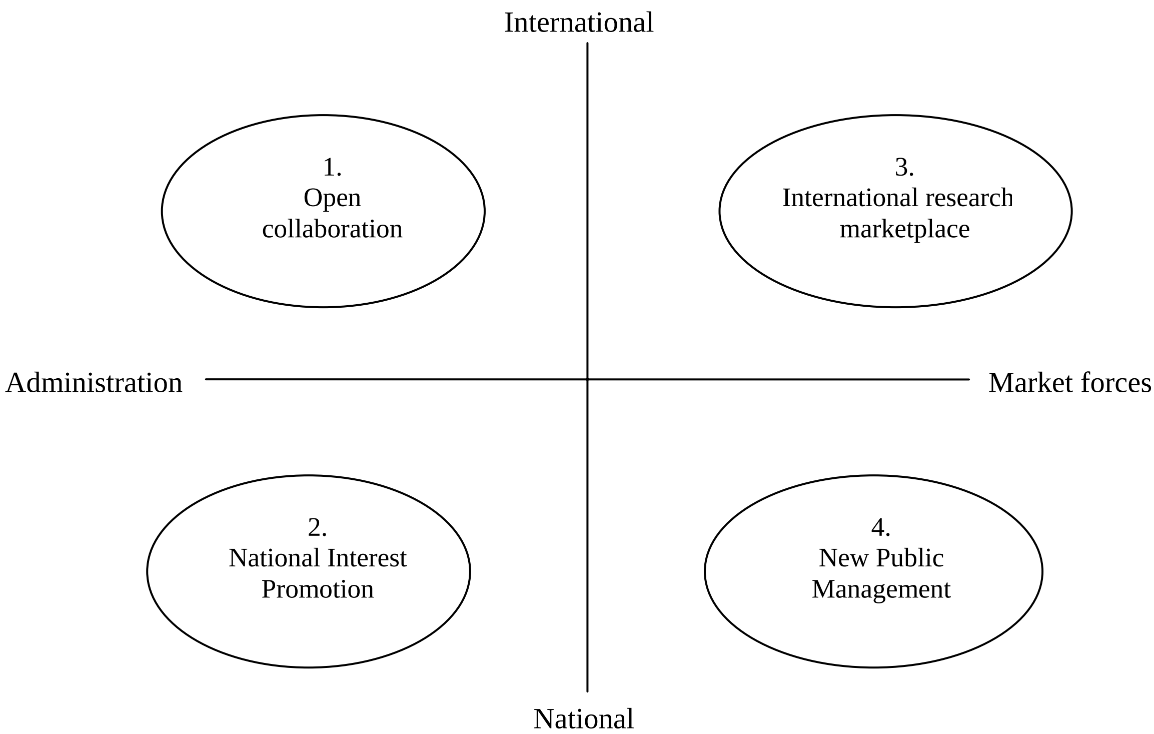
Drawing on the trends depicted in the previous section, as well as on other trends in higher education and society, this section proposes a set of scenarios for higher education research in a 20-year time frame. The scenarios build on the scenarios and methodology described in Vincent-Lancrin (2004) but with a focus on academic research.

Futures scenarios do not aim to predict the future, or to picture what a desirable future would be like, but merely aim to provide stakeholders with tools for thinking strategically about the uncertain future before them, which will be partly shaped by their actions and partly by factors beyond their control. The use of scenarios enables complex trends to be combined, tensions between people’s actions to be highlighted, emerging trends to be brought into the picture, and what trend reversal or radical innovation might entail. Scenarios are just possible futures, they do not have (or mean) to be likely or desirable. The challenge of scenario building is to strike a good balance between relevance (continuity with dominant and emerging trends) and imagination (discontinuity). This is why they often magnify trends or features that can already be observed at a small scale in some part of the world. Given that they try to help stakeholders better understand where they are and where they want (or do not want) to go, they do not really need to be realistic, but they must try to be interesting.

The four scenarios presented in this section build on the trends presented above: the increasing importance of knowledge; the growth of private funding and decline of government funding; the rise of competition from other sectors in basic research; the growing collaboration and competition at the national and international levels; the growing demand for accountability and transparency from governments and civil society; the new opportunities offered by technology progress; and the persistence of mass higher education systems (or continuing massification where it has not reached its peak).

A simple way to present scenarios is to select two key dimensions that would design a possibility space and emphasise some strategic directions. As shown on Figure 3, the possibility space has been designed around two dimensions: administration versus market forces; international focus versus national focus. The horizontal axis emphasises the governance pattern of the whole system: is it governed by administrative rules, which are more supply-driven, or does it become demand-driven, like on a market? It is noteworthy that a demand-driven system with market forces does not necessarily involve private for-profit higher education institutions. The vertical axis emphasises the depth of international integration in higher education. While participating and responding to globalisation is and will continue to be a challenge and opportunity for higher education, leading to both collaboration and competition, the national (or even regional) missions of higher education systems are still important and may become increasingly important in the future. Although we tend to take globalisation and internationalisation for granted, we should also consider the possibility of a backlash against globalisation, following a war, a pandemy, or citizens' hesitations to go beyond a certain level of international integration.

Figure 3: Four scenarios for academic research



While these two dimensions somehow shape the scenario stories, one should bear in mind that they are multidimensional. This means that the combination of some of their features is to some extent arbitrary. Technology is, for example, a cross-cutting force that could have a role in all scenarios, although it is mainly emphasised in the first scenario (where it could be a real driver). Scenarios must indeed be different enough to generate interesting discussion, which implies making choices. Nothing prevents stakeholders from making different choices, though, and combining the details differently into new scenarios of their own.

To help understand how they have been built, it might help to explicit how they relate to the previous sections of the paper. Scenario 1 mainly emphasises the trends depicted in sections 1, 5, 6 and 7. Scenario 2 draws on the current state of the art (the dominance of government funding through general university funds, growing importance of research), on the rise of geopolitical concerns reflected in the recent growth of military research, and finally on a reversal of the trends of section 5. Scenario 3 amplifies the trends pictured in sections 3, 4 and 5. And scenario 4 combines the trends highlighted in sections 2, 3, keeping at their current level the trends of section 4.

The four scenarios are the following.

Scenario 1: Open collaboration

In this scenario, one can imagine academic research remaining mainly publicly funded and very internationalised in a way that involves more collaboration than competition. This scenario is very much driven by technology and by the ideal of free and open knowledge – an ideal that civil society could increasingly impose on the grounds that academic research is largely paid for by taxpayers and should thus be freely available and following the lobbying of some patients' associations. There could also have been a backlash against patenting and intellectual property rights, regarded as an inefficient means of supporting innovation, not the least because of the existence of international networks of repositories of knowledge and research available through the Web. In this scenario, global networking is important and goes beyond higher education institutions, involving industries as well as individuals and concerned groups. Governments across the world can easily share their large research investments since they can be remotely operated, benefiting research teams scattered across the globe. While there is still a strong stratification of higher education institutions, or, in some countries, of research departments, some attracting much more funds and others and having different working conditions, this technology-driven networking induces much quicker spillover in the lower ends of higher educations systems as well as in developing countries. The hierarchy between higher education institutions is more relevant for the recruitment of academic researchers than for students. Indeed, academics and students in less prestigious higher education institutions could now access research tools and recent knowledge that were difficult to access before: recent research is indeed available on the web in real time, as well as new data sets on which can be used for new research and new simulation, computing and visualisation tools, and virtual "collaboratories" are open to everyone. Cutting edge academic research requiring heavy investments has thus democratised and crosses national borders. The media sometimes question the model when a foreign company develops a new product thanks to this open sharing, stressing the tension with the traditional economic logic, but its defenders argue that the reverse has also been true in the past and that the knowledge has actually been produced internationally. Although sensitive research is classified, some people fear that this proliferation of knowledge facilitates terror attacks. Finally, there are still some debates about the digital and knowledge divide between developing and developed countries, but everybody acknowledges some improvement compared to 20 years ago.

Scenario 2: National interest promotion

In this scenario, higher education would remain mainly publicly funded and administered, academics keeping their control over the research process as trusted professionals. Governments have put a strong emphasis on the national missions of higher education. Higher education institutions have become more embedded in their local communities and regional economy. A growing scepticism about internationalisation has indeed grown in the population, for a variety of reasons including recent terror attacks and wars, concerns about the rising number of immigrants, and the feeling that national identity was becoming threatened by globalisation and foreign influence. For geo-strategic reasons, governments have launched ambitious new military research programmes and have classified an increasing number of research topics in natural sciences, life sciences and engineering. International collaborative research continues, but with a more limited number of "friendly" countries. As many research outcomes have been increasingly regarded as strategic for the country, for economic or military reasons, the scope of academic research has somewhat diminished (while government research has regained ground). Albeit a small number of elite higher education institutions and research departments continue to be very internationalised, and to keep their top ranks nationally, the average higher education institution has research interests that are more related to their immediate neighbouring cities and regions. And in the public, academic research is associated with humanities and social sciences, two fields valued for maintaining national culture alive. Other fields of academic research have become more integrated with local economies, but thus less visible nationally. Academics continue to teach and to research, but teaching has become more clearly their first objective, and research, a welcome by-product—an arrangement that was found to match students' and policymakers' expectations.

Scenario 3: International research marketplace

In this scenario, one could imagine that higher education institutions compete globally to provide research services to governments, businesses and civil society as for-profit institutions. The liberalisation process at the WTO now encompasses research services supplied by higher education institutions, be they public or private. Academic research had become very close to a great deal of research carried out in the business sector, which undertakes a good share of basic research now; and it was equally funded by public and private sources, with the dramatic increase of revenues from their licensed discoveries, and their growing involvement in the business sector. Most people agreed that there was thus no longer any reason not to expose research services from the higher education sector to worldwide competition—or at least most of it, as most countries refused to make any commitment in the GATS for some research sub-sectors that they considered "vital" to their national security. Research and teaching are currently viewed as distinct services, as they have always been in the GATS, and higher education institutions have increasingly disintegrated their activities, concentrating on what they considered to be their core business (either teaching or research). So-called "research universities" thus hardly teach (when they continue to do so), while average higher education institutions carry out some supply-driven research but with small budgets. There is a fierce competition for academic researchers worldwide and between institutions to attract research super-stars. While cross-subsidisation of commercial research is strictly forbidden, academics are encouraged to carry out some disinterested research as a remedy to possible market failures. Basic research projects are still funded by governments, but following a tender to which all research centres in the world can—and do increasingly—apply. International rankings have first helped governments and private organisations and foundations to sort out the best institutions and research departments, but the research business has become so concentrated that these rankings are now useless. Outsourcing research to countries where research labour costs are still much lower than in the OECD area has proved to be very cost-efficient, and has been duly celebrated by taxpayers. Social scientists and journalists sometimes complain about the lack of relevance of some research, as foreign providers tend to downplay some cultural and historical features of the country, but the internationalisation of research teams should solve the problem. Although formerly "emerging countries" have gradually imposed their competitive advantage in some fields (technology in India, agronomics in China, etc.), some former developing countries are now "emerging". However, the United States is still the top exporter of research services, specialising in high-tech and capital intensive research.

Scenario 4: New Public Management

In this scenario, academic research remains mainly publicly funded but with a public management that makes extensive use of quasi-market forces. Higher education institutions are now autonomous. They still depend on the public purse for a significant share of their budget but have managed to diversify their funding sources, thanks to foreign education markets, the deregulation of tuition fees, the patenting of their academic research and their growing financial links with the business sector. The distinction between the higher education sector and the private non-profit sector does actually no longer make much sense, as most resources of university are now private, coming from students' households, business and private foundations. The division of labour between institutions has become stronger, most of them specialising in different missions regarding teaching as well as research—a differentiation that has not prevented most of them from continuing to carry out both research and teaching. Most higher education institutions have continued to allocate some research funding internally on their own funds. But the bulk of the allocation of public funds for academic research is generally indirect, financing separately budgeted research projects according to peer-reviewed selections. As a result, there is more competition nationally between higher education institutions and research money has been concentrated in a small share of them. (Only a small amount of research funding does actually cross national borders, except within the European Union where the recently created European Research Council funds an increasing share of European academic research.) Institutions are now much more accountable to the state and to their other financing sources. Higher education institutions still benefit from their research prestige to attract the best students and set their level of tuition fees. Some people recurrently voice their concern about the widening gap between elite and average institutions in terms of funding and quality, whereas others argue that concentration is the most efficient way to use a limited public budget, especially as advances made by the research institutions are then democratised by teaching institutions.

Scenarios aim at engaging stakeholders in discussion about strategic choices. So where are we and where could we go? What future do we want? What can and should we do to achieve it? Where are we probably going? While the paper proposes some possible answers to the first question, the subsequent questions are beyond its scope.

Here are just two comments for the discussion.

First, the chosen scenarios show that internationalisation and particular modes of provision (public or private) are conceptually disconnected. Internationalisation does not necessarily involve trade or liberalisation (scenario 1), although it can (scenario 3). Conversely, market mechanisms are not necessarily related to private provision or to internationalisation: they could be used in a public management framework (scenario 4), with public higher education institutions responding to market incentives. However, an important question to discuss is under what conditions a scenario would be sustainable (or stable). For example, the level of public funding seems to be an important factor for the "new public management" scenario to be sustainable: if this level diminishes beyond a certain point (to be determined), one would probably rapidly end up in the "international research marketplace" scenario.

Second, the question of the concentration or even distribution of academic research across higher education systems features in all scenarios, and ranks high in the policy debates. As shown in section 3, concentration of research already exists to a lesser or greater extent. And the strength of the link between academic research and teaching also varies accordingly across and between systems. To what extent should a country concentrate its academic research (or let it concentrate)? And if this concentration is desirable, what would be the best means? Linking academic research and teaching from the postgraduate level only? Separating academic research and teaching to a greater extent, as it is already the case in some countries? Redirecting incentives towards teaching (as the higher education economy is currently almost exclusively based on research)? What kind of effects would have these different types of differentiation? Finding the right balance at system level for higher education systems to both produce high level research and meet social and educational objectives at a reasonable social price will indeed continue to be one of the challenges of the next decades.

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