Economics of Education. Part 6. Costs and Benefits of University Research

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1. Introduction

Success is regularly identified with expansion and growth. Any organisation sustaining a nominal annual increase averaging 10% for 40 years would be recognised as highly successful. During the years 1955-1995, the national income of Japan grew at this rate. Over the same period, an even larger increase in funding of 12% per annum is recorded for Japanese universities.

Since 1955, the number of universities has doubled and the number of students has quintupled. The initial growth was in response to social demand and individual aspiration but increasingly expectation has focussed on the ability of universities to satisfy the demand for graduates in a changing and technically advanced economy. The success with which this has been achieved and the resulting economic benefits - for the nation as a whole and for university graduates as a group - has been substantial and is well documented.[1]

Provision for growth in the numbers of students and teachers has also facilitated growth in university research. Moreover, while growth in the number of university teachers has simultaneously increased the number of university research workers, research funding in universities has increased at the same rate as funding for higher education. Current funding (1996) for university research is reported to be Yen 2.98 trillion.[2] The benefits from university research are generally believed to be cultural and scientific rather than economic. Even so, at a time when accountability itself is perceived as increasingly beneficial, it is perhaps surprising that little attention has been focussed on a recurrent annual expenditure of this size.

The results of an attempt to estimate economic returns available from university research in Japan are presented in this paper. First it is necessary to establish the costs: this is done in Section 2, in which university research expenditures are analysed. Estimates of the direct and indirect returns arising from the research are examined and discussed in Section 3.

2. Costs of University Research

Expenditures by the three university sectors, national, public and private, are reported

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annually by the Ministry of Education.[3] These reports cover the aggregate costs incurred separately by the three sectors and do not attempt to distinguish between costs for education and research. For many academics, it is conceptually difficult to consider teaching and research as separable activities.[4] A nexus between teaching and research is firmly rooted in von Humboldt's nineteenth century philosophy, but pragmatically, modern research universities find few difficulties in allocating resources separately to teaching and research. Japanese universities are able to supply statistical data on their research expenditures to the official annual survey of research and development (R&D report).[2]

The data presented in the R&D reports extend across companies, research institutes and universities and provide a valuable source of information about research activity and intensity. However, there are some difficulties in reconciling the figures reported for university research with those contained in the Schools' surveys of the Ministry of Education. Thus the R&D reports reflect the dual funding basis for research by including the additional designated funds provided for specific research projects. More fundamentally, the R&D reports appear to ascribe about two-thirds of the operating costs of the universities to their research activities. This arises by attributing almost the full costs of all academic staff to research - with the implication that teaching is a complementary free good. Conversely, the context of the figures provided in the Schools' surveys suggests that they refer to the costs of teaching and consequently it is research that constitutes the free good.

Although the intellectual processes of research and teaching may well be inter-related, it is clearly not appropriate to double-count the costs of the labour involved. The labour costs included in the R&D reports for all sectors correspond fairly closely to the full employment costs of university teachers and about 60% of the costs of non-teaching staff. For purposes of international comparison, and with advice from the Ministry of Education, Martin, Irvine and Isard assumed that the labour costs for the national universities quoted in the R&D reports could be halved.[5] In regard to teachers, this assumption can now be validated and extended to all three university sectors; surveys have shown that, averaged over the whole year, close to half of the time spent on designated duties is allocated to research.[6] Detailed costings in the Schools' surveys show that about 40% of non-teaching staff costs can be attributed to central administration in the national and public universities, with the residual 60% distributed among faculty and departmental expenditures. Experience suggests that, given the demands of undergraduate teaching programmes, it would be unusual for administrative and technical support of research to constitute half of the work of all support staff in faculty or departmental offices and laboratories. To reflect this, and to include some allowance for the administrative support provided centrally, factors of 25% of the total costs of non-teaching staff together with 50% of the costs of teaching staff identified in the Schools' surveys have been used in estimating a more realistic value for the labour costs of university research.[7] For research institutes attached to universities, it is assumed that the full costs of labour are to be attributed to research.[8]

Other components of costs identified in the R&D survey can be characterised as consumables (materials and other expenses), tangibles (equipment, books and other tangibles), and property (buildings and land). The figures for consumables and tangibles given in the R&D report have been used without additional adjustments. These figures can be reconciled with those provided in the Schools' survey by assuming that:

(a) of the listed total expenditures for "education and research consumables" in the private university sector, one-quarter, and in the national university sector, half, is spent on research;

(b) of the listed expenditures for "education and research equipment" and for "books", in the private universities, one-third, and in the national universities, half, is spent on research;

(c) of the other expenditures on consumables and tangibles, in both private and national universities, one-quarter is spent on research.

The differing patterns of expenditure used for the two sectors correspond to the larger competing demands of undergraduate teaching programmes in the private universities (staff/student ratio: private universities, 1:23; national universities, 1:10); and the higher proportion of science and engineering research performed in the national universities. Expenditure in the public university sector conforms to a pattern intermediate between those of the private and national university sectors. Then, by incorporating the designated research funds (assumed to be distributed 70% on consumables and 30% on tangibles) a cost distribution is obtained similar to that shown in the R&D report.

No similar, simple correlations exist between the data in the two surveys for the costs of property. Over a period of years, the private universities have been recorded in the R&D reports as spending between 16% and 35% of their total property costs on property for research: in 1996 it was 35%. The national universities (10% - 19%) and public universities (2% - 24%) record lower ranges for their expenditures over time and lower proportions in 1996 (17% and 12% respectively). Yet in national universities, about a quarter of accommodation for academic purposes has been designated "research rooms"; and there is additional substantial provision for library, clinical, and laboratory and workshop space.[3] The recorded expenditures on property for research institutes are even less informative. Although the figures for research institutes in the two surveys might be expected to be similar, there appears to be no correlation between them. In the absence of any reliable data for actual spending on property for research, an arbitrary - but conservative - estimate of 25% of the total property costs as given in the Schools' surveys has been adopted for universities; and for research institutes, the low - but generally larger - estimates given in the Schools' survey have been used in preference to those given in the R&D reports. Fortunately, although spending on property absorbs a considerable annual sum, it represents only a minor component of research costs and estimates of total research costs are not sensitive to the precise values adopted.

Table 1. Estimated Research Costs in Universities and University Research Institutes, 1996.

Yen (millions)

Sector	Labour	Consumables	Tangibles	Property	Total
Universities					
National	339,041	218,914	96,465	43,831	698,251
Public	49,880	21,625	8,278	21,385	101,168
Private	515,458	232,468	68,033	62,714	878,673
Sub-Total	904,379	473,007	172,776	127,930	1,678,092
University Research Institutes					
National	44,111	33,883	14,557	321	92,872
Public	2,790	976	626	228	4,620
Private	7,942	4,553	2,090	747	15,332
Sub-Total	54,843	39,412	17,273	1,296	112,824
Total	959.223	512,419	190,049	129,226	1,790,917

Costs of research in 1996 obtained by combining the estimates for labour, consumables, tangibles and property are shown in Table 1. The overall total costs for universities and university research institutes are reduced to 71% of the total given in the R&D report, largely as a result of the lower estimate for labour costs adopted for the universities. The proportions of the total provided by the three sectors are:

for universities, national, 39%; public, 6%; private, 49%;

and for research institutes, national, 5%; public, 0.3%; private, 1%.

These proportions conform fairly closely to the numbers of academic staff in each sector. It is also evident that labour still provides the largest single component of research costs, accounting for approximately half of the totals in all three university sectors.

Table 2. Unit Costs for Research in Universities and University Research Institutes, 1996.[a]

Yen (million)

	Labour	Consumables	Tangibles	Property	Total
Universities					
National	6.47	4.17	1.84	0.84	13.32
Public	6.09	2.64	1.01	2.61	12.35
Private	7.16	3.23	0.95	0.87	12.21
All Universities	6.82	3.56	1.30	0.97	12.66
Institutes					
National	14.18	10.89	4.68	0.10	29.85
Public	16.17	5.84	3.75	1.37	27.66
Private	24.66	14.14	6.49	2.32	47.62

[a] Costs divided by the number of teachers reported for each university or institute sector.[2]

Amongst the sectors there are significant variations in the component costs for research. These become evident (Table 2) when the costs are expressed as unit costs, i.e. costs per university teacher. While some of these variations may be attributable to the different level of resources available to support research, a large part derives from the structural differences between the sectors. Differences in teachers' pay, average ages of professors, and the distribution of staff amongst academic grades, all contribute to variation in average labour costs.[6] But the even wider variations shown for consumables and tangibles are indicative of differences in the distribution of research amongst subject areas. Substantially higher costs are associated with research in science, engineering and medical science: these are reflected in the higher unit costs shown for the national universities, which are predominantly committed to research in these areas. Similarly, the high unit costs for property shown by public universities can be attributed to rapid expansion of their facilities for research. The much higher unit costs for the research institutes correspond to the engagement of their staff full-time in research; however, the particularly high unit costs for research institutes attached to private universities appear to originate in the large proportion of their employment costs attributed to support staff (ratio of costs, support staff/teachers 1.0; cf national university research institutes, 0.46; public university research institutes, 0.3).

Table 3. Unit Costs for University Research in Designated Areas as Multiples of Teacher's Pay, 1996.

Research Area by University Sector [a]	Cost as Proportion of Cost of whole Sector	Average Teacher's Pay Yen million [b]	Costs as Multiples of Teacher's Pay (1996)				
			Labour	Materials and Expenses	Equipment	Property	Total
Universities							
National	100%	5.22	1.24	0.8	0.35	0.16	2.55
Public	100%	4.93	1.24	0.54	0.20	0.53	2.51
Private	100%	5.35	1.34	0.6	0.18	0.16	2.28
Social Sciences							
National	8%	5.09	1.29	0.45	0.07	0.05	1.86
Public	19%	5.08	1.19	0.38	0.09	0.33	2.0
Private	36%	6.64	1.20	0.44	0.08	0.09	1.83
Science & Engineering							
National	58%	5.63	1.16	0.97	0.51	0.23	2.88
Public	31%	5.33	1.22	0.65	0.37	0.60	2.83
Private	22%	5.67	1.37	0.72	0.41	0.17	2.66
Medical Sciences							
National	23%	4.61	1.32	0.92	0.26	0.09	2.88
Public	41%	4.67	1.30	0.61	0.19	0.78	2.88
Private	27%	4.05	1.45	0.97	0.21	0.33	2.95
Education & Other							
National	11%	5.18	1.17	0.30	0.16	0.10	1.73
Public	9%	4.76	1.20	0.35	0.11	0.09	1.74
Private	15%	5.55	1.19	0.38	0.11	0.12	1.80
Research Institutes							
National	100%	9.15	1.56	1.19	0.51	0.01	3.26
Public	100%	7.23	2.31	0.81	0.52	0.19	3.83
Private	100%	9.21	2.68	1.54	0.70	0.25	5.17

[a] Social sciences includes humanities; science and engineering includes agriculture; medical sciences includes dentistry, pharmacy and nursing.

[b] Teacher's pay (1996) for research in universities is put at half of the average reported pay for teachers in the appropriate research area of each university sector; for research institutes linked to universities, total average reported pay is used

The differing requirements of subject areas impose wide variations in research costs. It is convenient to identify four subject areas: social sciences and the humanities; science, engineering and agriculture; medical sciences; and education, the arts, and other disciplines. Measured by the number of university teachers, levels of research activity are fairly uniformly distributed over these four areas (26%, 30%, 28%, 17% respectively). The distribution of research costs shows much greater variation, with almost three-quarters of total costs incurred in the areas of science and medical sciences (Table 3). These are accentuated by the differing emphases on the subject areas found in the university sectors. The major area for research in the national universities, both by staff numbers and by costs, is science and engineering; in the public universities it is medical sciences; and in the private universities it is social sciences. Actual costs of research per teacher show only small variations between the 3 university sectors (+/- 5%); and with the exception of the social sciences this is also true for the sets of the 4 separately identified areas of research. Similarly, relative to teacher's pay, only minor differences appear between the 3 university sectors for research costs either in the research areas or in the overall averages. Major difference are shown in both actual and relative costs between the 4 research areas, with unit costs for research in science and engineering being some 25% above the average, and those for "education and other disciplines" some 25% below; interestingly, the average actual unit cost for research in medical sciences falls below the overall average cost for both national and private universities, though not for the public universities. In all areas, labour costs contribute substantially to the overall costs. For all three university sectors, labour costs account for about two-thirds of the total costs in the two areas of the social sciences and education and other disciplines; but for science and medical sciences, the proportion falls to below half. It is the high costs of consumables and tangibles (mainly equipment) for research in science and medical sciences that make them the more costly areas. Equipment imposes a lower cost on research in medical science than in science and engineering but the lower overall unit cost for medical science can mainly be ascribed to the large proportion (about 50%) of lower paid, junior grades of university teachers employed in these faculties, especially in the private sector.

Resources available for research extend beyond those provided from current expenditure. This is self-evident for property and equipment, both of which retain value over extended periods of time. In both cases, the accumulated annual expenditures constitute investment of capital. Recently it has become increasingly common to identify the continuing value of accumulated knowledge similarly as "knowledge" "intellectual" or "research" capital.[9] To this end, research expenditure over time on labour, materials and other related costs can be regarded as a measure of the accumulating knowledge.

For accountancy purposes, public expenditure on property is commonly written down, or written off, over 40 years; and expenditure on equipment over 10 years. Commercial practice reflects realities more appropriately by using the shorter periods of 25 years and 7 years respectively. Practice with regard to the costs of research varies according to accounting conventions and taxation regulations: in Japan it is permitted to write off commercial investment in research over a period of 5 years. However, this needs to be distinguished from the period over which benefit from research can be expected. The period of commercial benefit from research capital appears to vary with the sector of industry. In America, estimates indicate that it appears to persist for periods ranging from 5 years for scientific instruments to

8 years for electronics, and to 9 years for the chemical and pharmaceutical industry.[10] In Japan, the available data suggest that, across the whole of industry, research capital retains commercial benefit for an average of 6 years (see Section 3).

Table 4. Estimates of Accumulated Capital for Research in Universities, 1996.

Million yen (1990)

	Labour, Materials & other Expenses [a]	Equipment [b]	Property [c]
Universities			
National	1,812,317	352,964	387,798
Public	223,256	27,432	142,319
Private	2,406,114	296,436	823,213
Total	4,441,687	676,832	1,353,330
Research Institutes			
National	269,447	64,267	27,160
Public	7,488 [d]	1,924	907 [e]
Private	39,639	4,258	10,890
Total	316,574	70,449	38,957

[a] Non-linear depreciation of expenditure on labour, materials and other expenses over 10 years by using factors: 0.945, 0.85, 0.725, 0.585, 0.44, 0.3, 0.175, 0.075, 0.015, 0.005. Linear depreciation increases estimated accumulated capital by about 20%.
[b] Equipment depreciated linearly over 7 years.
[c] Property depreciated linearly over 25 years
[d] There is a discrepancy between the figures reported in the Schools' and R&D surveys. The total, yen 7,488 million is derived from the Schools' survey figures for labour and the figures in the R&D report for materials and other expenses. If the higher figure in the R&D report for labour were used, the total capital would become Yen 10,995 million.
[e] Land costs are reported as zero for research institutes linked to public universities.

Analogous procedures can be applied to evaluate the accumulated capital currently available for research in universities. Expenditures on labour, materials, expenses, equipment and property were obtained by the procedures already described from the R&D reports and Schools' surveys. Expenditure on property and equipment was amortized linearly over 25 years and 7 years respectively, in accord with standard commercial practice. To reflect the longer life expected for economic returns from university basic research, a period of 10 years was arbitrarily selected for amortisation of expenditure on labour, materials and expenses, with a non-linear decay function similar in form to that shown to be appropriate for amortisation of commercial research. The results, expressed in 1990 Yen are shown in Table 4.

Table 5. Accumulated Capital per Teacher for University Research, 1996 [a]

Yen (1990) million

Research Area	Labour	Materials and Expenses	Equipment	Property
University Totals				
National	21.7	12.9	6.7	7.4
Public	19.1	8.2	3.4	17.4
Private	23.0	10.5	4.1	11.4
Social Sciences				
National	21.9	7.1	1.2	4.1
Public	19.0	6.0	1.5	9.7
Private	25.7	9.5	2.3	10.9
Science & Engineering				
National	22.0	16.9	10.5	10.4
Public	20.3	10.6	6.6	29.5
Private	24.9	13.2	10.1	16.8
Medical Sciences				
National	21.2	12.6	4.5	4.3
Public	19.0	8.8	3.0	17.0
Private	18.9	12.7	3.7	7.7
Education & Other				
National	20.4	4.9	3.0	5.7
Public	19.1	8.2	3.4	17.4
Private	23.0	10.5	4.1	11.4

[a] Accumulated capital estimated as in Table 4.

Expressed as accumulated capital per teacher (Table 5), the results confirm the generally uniform distribution of capital when allowance is made for the distribution of research activity among the university sectors. The longer-term implications of the current annual expenditures shown in Table 3 are largely confirmed and a number of commonly held perceptions are given substance. Thus, the lower capital investment in national university buildings is clear, especially in comparison with the public universities. Similarly the higher salaries paid in the private universities become evident in a correspondingly higher investment in labour. Capital requirements for research in science and engineering, in contrast to conventional expectations, are shown to be significantly higher than those for medical sciences. This is particularly evident in regard to equipment and property and may indicate a concealed subsidy from hospitals to medical research or an inadequate separation of clinical and academic costs.

3. Economic Returns from University Research

Evidently there is a great amount of university research, conducted at considerable expense. It constitutes 0.4% of GDP, 12% of total expenditure on research and 49% of the costs of universities in Japan. This is accepted and encouraged by government and governing bodies as an essential component of university life. All academics expect to engage in research and indeed for many it provides the principal attraction of academic life. The pre-eminence ascribed to research in universities arises from a multiplicity of motivations. For individuals, its purposes range from intellectual satisfaction, through personal status, to advancement of knowledge. Institutionally, a reputation for research confers respectability in the academic community and esteem in society at large.

Expenditure on research, like expenditure on education, represents a decision to forgo the advantages of immediate consumption in favour of greater future benefits. Consequently, while it is appropriate that combining research and education in universities satisfies the aspirations of academics both as individuals and collectively in institutions, it is desirable to identify the benefits that accrue to the wider community. Increases in the stock of useful knowledge provide contributions to national life, culture and prestige; new products and new industry emerge from new results. Indirectly a major effect is to equip graduates with a familiarity with recent developments in knowledge, concepts and techniques. The impact of well-educated university graduates on an increasingly knowledge-based society is clearly a significant factor in determining the levels of support for university research. Continuing growth of government support is accompanied by increasing emphasis on raising the quality of research training and of research itself.[11] There is a firm economic basis for all of this: research contributes to growth in productivity and to increase of national wealth.

Industry and commerce provide direct evidence for this. Profitability of companies undertaking R&D is consistently and substantially greater than those that do no research. Not surprisingly, industrial spending on R&D in Japan has increased at an average real rate of 5.5% over the past 25 years, and the proportion of R&D funded by industry has grown correspondingly. Overall expenditure on R&D in Japan is high, at about 3% of GDP though the proportion funded by government is now less than one-quarter, low by international standards even when allowance is made for the small defence-related budget.[12] Support for R&D in Japan provided by the government amounted to about Yen 3.2 trillion in 1996. Companies receive about 4% of this; universities and university-based research institutes receive about 33%.[13]

A relationship between R&D and increased productivity is well established in economic theory. In a static economic system, output is determined by two factors: labour and capital.[14] Growth arises from increase in the quantity of labour or capital, or from a change in the production function that increases the effectiveness with which they are used - for example, by advances in technology. Abundant evidence indicates that, in modern economies, such changes, designated total factor productivity (TFP), contribute significantly to observed growth. In Japan, 40% of the growth in GDP over the period 1970-1990 has been attributed to TFP.[15]

Provision for such growth is incorporated in the neo-classical economic model by adding a third factor. The third factor, "knowledge capital", seeks to identify explicitly the basis by which the productivity of human and physical capital is enhanced.[16] Application of this extended model requires estimates of all three sources of capital. While there may be some problems in identifying accurate data for accumulated physical capital, estimates of knowledge capital are particularly difficult to obtain directly. Extensive studies have shown that an adequate proxy for knowledge capital can be provided by accumulated expenditure on R&D.[16] The defect, that this uses an input (R&D expenditure) to estimate an output (knowledge capital), does not appear to invalidate its use; where comparison with direct estimates of knowledge capital has been possible, its utility has been confirmed.[17] Many reports identify the importance, in Japan and elsewhere, of growth generated from knowledge or research capital across individual firms, complete sectors of industry or industry as a whole. A measure of this is given by the rate of return on research capital. For a wide range of manufacturing industry in Japan, reported rates of return over the period 1960 - 1984 lie in the range 22% - 81%,[18] values that are notably higher than the 13% reported for earnings from physical capital;[19] and, by using figures for total expenditure on R&D in Japan during the 20-year period to 1996, an estimated rate of return of 15% can be derived across the whole of the Japanese economy.

This economic analysis indicates that the impact of expenditure on R&D on national productivity and wealth has been substantial. Over the period 1970 - 1990, GDP increased by Yen 212 trillion (1990 Yen). According to the O.E.C.D. estimates, 40% of this growth can be attributed to TFP and hence to investment in R&D.[15] As universities account for 12% of total R&D, it could be argued that university research has contributed proportionately to this growth: that is, university research has generated growth of Yen 10 trillion in the national economy over the period 1970 - 1990 and so contributed 2.4% of GDP in 1990.[20] Such figures might well be viewed with caution.

Any suggestion that the benefits of university research can be quantified in this simplistic way could clearly be challenged by a range of powerful arguments. Indeed it is arguable that, as the principal purpose of academic research is the advancement of knowledge, the formation of a public good through open publication and dissemination cannot register a financial return. However, a tendency to evaluate knowledge is shared by both commerce and government. Increasingly there are demands to quantify benefits from research performed with public money; and public sector finance seeks to identify comparative returns from investment in competing public goods - health care, education, environmental management, social service. There appears no obvious reason why academic research should be exempted from similar treatment.

There are clear distinctions between university and commercial research in two respects: the levels of support from government and the emphases given to basic research. Government support is needed both to sustain university research and to correct an imperfect market. The market for research is inherently flawed in that profits from commercial research become available through involuntary "spillovers" to those who have not contributed to the research.[21] Spillover is important as a means of allowing new developments to diffuse rapidly and widely through industry, and is encouraged by the nature of patent law in Japan.[18] But by reducing returns available to those funding research, it tends to restrict the total amount of research to a sub-optimal level. This is well illustrated by the rates of return from investment in research, which, although good, are lower to the individual companies performing research (private return) than they are in aggregate to the whole of the corresponding sector of industry (social return).[17, 22] When a market is intrinsically unable to deliver a necessary good, it becomes a responsibility of government to intervene.

Apparent inability to capture an adequate return from basic research has been perceived to present a particular difficulty so that it constitutes no more than 7% of industrial R&D in Japan, low in comparison with the proportion in other advanced economies.[12] Universities provide a major contribution to basic research. About two-thirds of all university expenditure on research is classified as "basic"; and in total, universities perform 44% of all the identifiable basic research in Japan. Universities make the predominant contribution to research in the social sciences, humanities, arts and education, accounting for over two-thirds of all basic research in these areas. They are also responsible for over one-third of all the basic research in science, engineering, agriculture and medical sciences, a proportion equal to that provided by the whole of industry. It is notable that the relatively low level of direct government subsidy results in over half (53%) of the universities' contributions to basic research coming from the largely unsubsidised private universities, which provide two-thirds of university basic research in the social sciences and related disciplines and 40% of university basic research in the areas of the science disciplines.[23]

Even though the amount of basic research performed by companies in Japan is a small proportion of their total expenditure on R&D, it represents almost a quarter of all basic research and one third of all basic research in science, engineering, agriculture and medical sciences. Moreover, and in contrast to other developed countries, little of the cost is provided by government subsidy. Despite the inherent inability of a company fully to capture the benefits,[21, 24] the incentive for companies to invest in basic research must be assumed to be financial rather than philanthropic. It may well be possible for a company to combine a "first mover" advantage with other associated benefits sufficient to justify a long-term investment in basic research on financial grounds.[25] Certainly, the results show that commercial returns from basic research are high and are in fact substantially greater than those identified from applied research.[26] The high private and higher social returns from basic research performed commercially suggests both that its quantity is less than optimal and that, by implication, the potential value of university research must be substantial.[27]

The value of university research has been confirmed by Mansfield in an important series of studies.[28] Over the periods 1975-1984 and 1986- 1994, surveys showed that about 10% of new products and processes introduced commercially in the US were dependent on recent university research; and in addition that introduction of a further 7% was very substantially facilitated by university research. Similar results have been reported from Germany although the scale of contributions from universities was smaller.[29] With knowledge of the value of sales of the innovations, and estimates of total expenditures on all university research, it was possible to calculate a rate of social return of 28%. The procedure used to calculate this rate of return is explicitly cautious, incorporating a benefit stream restricted to 7 years, a high rate of interest, and a substantial time lag. Even so, by conflating the return from academic basic research with that from the necessary additional research and development, it may not properly identify the return to university research.

University research as a public good is not a free good. Costs are incurred both in the additional R&D required to achieve a commercial innovation and through the time lags entailed. There are similar costs associated with intra- and inter-industry diffusion of knowledge. Within a given sector of industry, information about new products and processes diffuses rapidly and by a variety of mechanisms. Yet the subsequent costs of developing a new commercial product remain high: they average about 70% of the original costs of innovation.[30] Even so, the ability to assimilate and exploit new research or spillover appears to depend on the existing level of research inside a company and, in particular, on the amount of basic research a company performs.[31] This ability, identified as "absorptive capacity", arises from familiarity with current developments in basic research and emerging techniques and may be achieved most effectively through participation in basic research.

Awareness of the value of creating absorptive capacity might have been expected to increase the amount of basic research done by companies. While the quantity of commercial basic research has increased over the past 25 years by a factor of 2.4, it now constitutes a smaller proportion of companies' R&D expenditure. If the evident commercial benefit from expenditure on basic research has already been discounted, socially sub-optimal levels of basic research are likely to continue. It follows that basic research from universities is needed and is socially as well as culturally desirable. Moreover, it becomes economically advantageous if the costs of research in universities are not greater than those in companies.[24] The data suggest this to be so. Input costs, averaged over the number of research workers in 1996 were: for companies, Yen 25.1 million; for research institutes, Yen 42.7 million; for universities, Yen 12.6 million; and for university-linked institutes, Yen 31.3 million. However, as university teachers devote only half their time to research, the comparable full-time equivalent cost for universities is Yen 25.3 million, identical with that for companies.[32] Output is less easily quantified. A generally accepted measure of research output is provided by publications. Direct comparison between industry and universities is impeded by both a paucity of data and a problem of comparability. A crude comparison shows that, on average, each regular researcher in industry generates one patent per year, and each fte university teacher in the areas of science engineering and medical sciences produces one refereed journal article;[33] and further, that rates of publication of both patents and journal articles increase at the same rates as increases in R&D funding. More usefully, it has been possible to obtain comparable data for rates of publication of the 3 categories of research institutes - commercial, governmental and university-linked - if publications are defined broadly to include articles in journals, consultancy and research reports, conference and seminar papers, books, and patents. The results of a recent survey[34] show that, while similar rates of publication are achieved by researchers in government and university-linked research institutes, these are at double the rates reported by commercial research institutes. When allowance is made for differences in subject areas, the rates of publication for those in university-linked research institutes are similar to rates previously reported by university teachers.[5] While there are well recognised cultural and career criteria encouraging high publication rates in universities, by this measure it appears that university teachers are at least as productive as researchers in commercial institutes and hence, by inference, as those in industry.[35]

Access to university research as a public good does not restrict companies to benefits from universities in their own countries. There is evidence that some of the major Japanese companies increasingly look overseas, and particularly to America, for university collaboration.[36] This is though an increase on a very small base and a combination of geographical proximity, linguistic and cultural elements continues to offer a significant domestic advantage both in diffusion of new research and in transfer of technical research skills.[37, 38] Despite a popular belief to the contrary, Japanese industry now receives much less benefit from informal international diffusion than industry elsewhere[39] and remains dependent on Japanese sources for basic research. Prior knowledge, cited in patents, is largely obtained from basic research published by universities. According to the numbers of papers cited, companies in all countries depend largely on domestic universities, but Japanese companies are even more dependent on publications from Japanese universities than are American or European companies on universities in their own countries.[40]

The cumulative evidence appears to place the value of university research beyond question. Yet translation of the cultural, social and economic benefits of university research into quantitative estimates is impeded by the absence of direct evidence of financial return. Recently an indirect approach to resolve this problem has become accessible from developments in procedures for accounting for the commercial value of knowledge capital.[10] The relationship between R&D expenditure, capital and earnings for a sample of 800 US companies was analysed by Lev and Sougiannis for the period 1975 - 1991. Commercially effective lifetimes for R&D capital varied for a number of research-intensive industry sectors from 5 - 9 years; returns from R&D capital were estimated at 166% - 263% over the same periods. By applying a simplified variant of Lev's procedure, it has been possible to obtain an estimate of the effective lifetime of R&D capital averaged across the whole of R&D-performing Japanese industry. Iterative regression of R&D expenditure with respect to sales on the reported net operating profits showed good correlation and indicates an effective lifetime of 6 years. Total return on R&D capital over the full period of 6 years amounts to 203%; by using the stream of earnings corresponding to the non-linear rate of depreciation of R&D capital, this represents an annual rate of social return of 28%. These results are closely similar to those obtained by Lev and Sougiannis for the second half of their sample, characterised as "All other R&D Industries", which showed an average effective lifetime for R&D capital of 6 years and an overall return of 183%. Similarly good agreement is shown between the results reported by Lev and Sougiannis for research-intensive industries and those obtained by Goto and Suzuki from their full and elegant analyses of data from a range of research-intensive Japanese manufacturing industries, which indicated effective lifetimes for R&D capital of 4 - 7 years and annual rates of return averaging 40%.[17]

As the annual investment in university research is known, it is possible to extend the parameters used to calculate industry-wide R&D capital to include the universities. One important adjustment is required before this can be done. Extensive evidence has identified a lag of up to 7 years between availability of academic research and generation of a return.[28] This lag can be attributed to a combination of the time taken for diffusion of knowledge from universities together with the time taken subsequently to develop a marketable product. Equally, academic experience would support the belief that the effective lifetime of academic research is closer to that of two generations of graduate students rather than that of one generation. Although advancement of knowledge in areas of new technologies is rapid, this is not general for research-intensive developments. Results obtained from chemical and pharmaceutical manufacturing, a sector of industry closely linked to academic research, indicate that its R&D capital enjoys an effective lifetime of 9 years in both America and Japan.[10, 22] To reflect these characteristics, an arbitrary assumption has been made that an average effective lifetime for academic research can be put at 10 years, either intrinsically or to include a four year lag preceding a return on investment over the standard 6 years found for commercial research across all industry.[41]

Extending the lifetime of university research capital has the effect of attenuating the stream of benefits and reducing the rate of return. If the overall return is held constant at 203%, extending the effective lifetime to 10 years reduces the potential annual rate of return from university research capital to 16%; introduction of a 4 year lag, during which there is no return, reduces the potential rate to 11%. There are arguments to support a belief that the overall return from investment in university research, and hence the annual rate of return, should be greater than that estimated for commercial research.

- The return derived from commercial R&D data is a quasi-social rate, i.e. it identifies only the return to industry and does not include that derived from consumer surplus in the wider community; in contrast, benefits from university research, as a public good, constitute a true social return. Quasi-social returns cannot be greater than social returns.[42]
- The commercial average yield is reduced by inclusion of sectors of industry that have a low R&D intensity and generate low profits (*e.g.* agriculture, textiles, petroleum); university research has a uniformly high intensity.
- The proportion of basic research, which generates high returns,[26] is much higher in universities (66%) than in industry (7%).[12]

These arguments suggest that that the indicated values (16%, 11%) constitute a conservative base level for the potential return expected from academic research. A recent study of the results of publicly financed research in the US confirms that the average social rate of return will not be less than 16%.[43]

Table 6. Notional Earnings from University Research, 1996

Yen millions (1990)

	Non-Tangibles [a]	Equipment [b]	Property [b]	Total [c]
Universities				
National	951,145	24,707	29,611	1,005,463
Public	112,166	1,920	10,541	124,627
Private	1,231,499	20,750	65,787	1,318,036
Total	2,294,810	47,377	105,939	2,448,126
Research Institutes				
National	143,119	4,499	1,901	149,519
Public	3,557	135	63	3,755
Private	20,715	298	762	21,775
Total	167,391	4,932	2,726	175,049
Overall Total	2,462,201	52,309	108,665	2,623,175

[a] Earnings corresponding to capital derived from expenditures on labour, materials and other expenses, depreciated over 10 years (Table 4) by using the parameters: 0.11, 0.19, 0.25, 0.28, 0.29, 0.25, 0.2, 0.12, 0.02.

[b] Earnings corresponding to capital from expenditure on equipment and property depreciated linearly over 7 and 25 years respectively and yielding a return of 7%.

[c] Earnings corresponding to depreciation of R&D capital over 6 years with a further 4-year lag are reduced to ca 92.5% of the indicated totals.

Estimates of university research capital from non-linear depreciation of expenditure on labour and materials over 10 years are listed in Table 4. Capital accumulation on this basis is about 10% less than would result from conventional linear depreciation but the total is not sensitive to the precise parameters adopted. Alternatively, depreciation of university expenditures over 6 years reduces the accumulated capital by about 20% with respect to that from linear depreciation. Notional earnings potentially available from university research are in Table 6. These are estimated on the assumption that they match the overall benefits available from commercial research over an effective lifetime of 10 years. Notional earnings corresponding to linear depreciation of capital over 10 years are only slightly lower; potential earnings from depreciation of capital over 6 years are reduced by about 10%. The total annual potential earnings identified in Table 6 correspond to 0.56% GDP, substantially more than the current annual costs of university research (0.38%).[44]

At best, universities capture, through patents and licence payments, only a vanishingly small amount of these potential earnings. Payments from non-government sources to universities in support of research have more than doubled over the past 15 years but still provide less than 4% of research costs.[45] In general benefits are either captured by industry to appear as improved productivity, leading to increased affluence, growth of GDP and hence government revenue; or reach the wider community in the form of increased consumer surplus.

A lingering belief that much university research is incapable of yielding such a high rate of return is sustained by the failure to capture returns explicitly. While there are no tenable reasons to question the economic benefits from research in engineering, medical, natural or physical sciences, these doubts focus on university research in the humanities and social sciences. It is frequently suggested that research in these latter areas, which constitute about one-third of university research, is inherently less economically valuable. Indeed, in some academic circles this historic view of scholarship is vigorously defended. The attitude of government shows a curious dichotomy. Despite assertions of the importance of prioritising research in the social science and humanities, no priority areas have been listed.[46] No provision is made in the official R&D reports for companies to indicate expenditure on social science research; service industries (finance, insurance, welfare, wholesale and retail trade) and the whole of the service sector are excluded from the reports.[47] As the tertiary sector contributes two-thirds of GDP and contains its most rapidly growing elements, these omissions are notable. The increasing impact on national resources, public and private, of social and structural change implies significant growth in the demand for and value of research in the social sciences that apparently can only be provided by universities.[48] It follows that the benefits from this research should not be expected to be less than the overall average.

For the earnings potential of university research to be realised, the results need to be disseminated. The conventional route is through publication in academic journals. This continues to be a major and effective means of providing public access to research findings and one favoured by the academic community by virtue of the priority and prestige it confers. Expansion of publication through journals to accommodate the growth of research carries problems. Rising costs and lengthening delays encourage alternative modes of publication, notably through electronic publishing on the Internet. However, as it has become more widely recognised that high potential value resides in academic research, a fundamental conflict emerges between the responsibility of subsidised universities to supply a public good and the institutional and individual gain that it may yield. So, for work that evidently has commercial potential, full publication may be deliberately delayed to enable it to be protected through patents or by establishing copyright. Funding agencies and universities now routinely encourage such procedures. The practice is now commonly extended to protect ownership of material that would previously have been regarded as fundamental public knowledge (*e.g.* structure of the human genome); and also defensively to protect individual property rights, even for results with apparently little immediate commercial significance. Following implementation of the Bayh Dole Act, which allows universities in the US to capture financial returns from government-funded research, it has been noted that as the quantity of academic patents has grown, their quality - as indicated by the number of references they attract - has declined.[49] Increased emphasis on commercial development through entrepreneurial activity by university staff is also tending to reduce less formal dissemination of work-in-progress through seminars and discussion within the academic community in America. Some of these tendencies must be seen as counterproductive to efficient dissemination of results and, by reducing opportunities for critical comment, undesirable in sustaining research quality.

Dissemination becomes particularly effective if it occurs through collaboration.[50] The number of publications resulting from collaborative research between large Japanese companies and universities increased over the period 1980-89 by 156%.[51] These publications predominantly record basic research undertaken with Japanese universities. The importance of collaborative research is similarly recognised by Japanese academics, who report that one-third of all their publications arise from collaborations.[52] Collaboration provides prior access not merely to the codified knowledge placed in the public domain by publication but also to the more elusive, tacit knowledge arising from the specialised skills and inherent expertise acquired by performing research.[53] By its nature, tacit knowledge tends to remain embodied in research workers. Despite spillover, the high economic return to companies from participation in basic research[26] can plausibly be attributed to a combination of research absorptivity and an accumulation of tacit knowledge.[54] This is compatible with an increasing tendency of the more innovative and successful companies to encourage publication of their research results:[55] in doing so they signal high research productivity, identify areas for collaborative research and present an environment attractive to capable research staff.

Familiarity with new concepts and techniques is central to effective dissemination of research results. It places emphasis on linkages provided by collaborations, consultancies and networks of personal communication.[37] Recruitment of graduate students and post-doctoral researchers is perhaps the single most effective means of obtaining rapid transfer of basic skills and tacit knowledge from universities to companies. Strong professional networking in Japan facilitates access to universities; conversely, mobility of successful researchers between companies and universities is notably less significant in Japan than elsewhere.[53] The traditionally weak links between universities and industry, a deficiency of entrepreneurial academics, the limited involvement of academic staff in commercial consultancies, the small numbers of graduate students and the low value put upon them by industry, all must constrain dissemination of research knowledge and so limit the current level of social benefit derived from university research.

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1 For references see K. J. Morgan, Social, Public and Fiscal Rates of Return from Higher Education in Japan, *Higher Education - Daigaku Ronshu*, **26**, 219 (1997); Equity, Earnings and Education of Women in Japan, *ibid*, **30**,

157 (1999).

2 *Report on the Survey of Research and Development*, Statistics Bureau, Management and Coordination Agency, Government of Japan, 1997 and earlier years.

3 *Schools' Basic Survey*, Ministry of Education, Science, Sports and Culture (MESSC), Japan, 1997 and earlier years; *Survey on Financing of Private Schools and Universities*, MESSC, Japan, 1997 and earlier years.

4 See *e.g.* I. Moses, Teaching, Research and Scholarship in Different Disciplines, *Higher Education*, **19**, 351 (1990); P. Ramsden and I. Moses, Associations between Research and Teaching in Australian Higher Education, *ibid*, **23**, 273, (1992); R. Neumann, Perceptions of the Teaching-Research Nexus, *ibid*, 159; S. Rowland, Relationships between Teaching and Research, *Teaching in Higher Education*, **1**, 7 (1996).

5 J. Irvine, B. R. Martin and P. Isard, *Investing in the Future: An International Comparison of Government Funding of Academic and Related Research*, Edward Elgar, London (1990).

6 K. J. Morgan, *Universities and the Community*, RIHE International Publication Series, RIHE (1999). Responses to the surveys indicate that, averaged over the whole year and across all 3 university sectors, research occupies 50.3% of time spent on designated academic duties. The corresponding average working week is 44 hours (excluding professional and community activities). Employment in national, public and some private universities is contractually limited to 40 hours *per* week. If it were argued (as it has been *e.g.* for project SCORE in Australia) that employment costs are restricted to contractual hours, then the extra time spent on research constitutes unpaid voluntary overtime. On this basis the estimates of research labour costs would need to be reduced by up to 10%.

7 Costs for the national and public sectors are corrected by inclusion of a proportionate estimate of the research costs, including support and all associated costs, arising from teaching staff employed in hospitals. For the private sector, the financial data presented for universities includes hospital and institute costs. These cost are subtracted and a similar proportionate correction is made for the research costs of teachers employed in the hospitals. Labour costs include proportionate additions for superannuation, welfare and other charges.

8 This assumption appears to be valid for the largest sector, research institutes attached to the national universities. For research institutes attached to public universities, the costs of labour in the Schools' survey have recently (since 1990) become substantially smaller than those quoted in the R&D report; conversely, for those attached to private universities, the Schools' survey data indicate higher costs, perhaps arising from the high proportion of their labour costs attributed to administration. The figures in Table 1 are based on those in the R&D report; overall the discrepancies are small in comparison with the total costs of research.

9 B. Lev, R&D and Capital Markets, *J. Applied Corporate Finance*, **11**, 22 (1999).

10 B. Lev and T. Sougiannis, The Capitalization, Amortization and Value-Relevance of R&D, *J. Accounting and Economics*, **22**, 107 (1996).

11 A. Arimoto, in *Higher Education Reform for Quality Higher Education Management in the 21st Century*, RIHE International Seminar Reports, **11**, 6 (2000).

12 Science and Technology Agency, *White Paper on Science and Technology 1996*, Japan Science and Technology Corporation Information Center for Science and Technology (1996).

13 Reported allocation of government support for R&D is: companies, 4%; research institutes, 48%; universities and colleges, 49%. The statistical category "Universities and Colleges" includes universities, colleges, university-linked hospitals and research institutes and a number of national research institutes. The subsidy provided for universities and university-linked institutes constitutes only 83% of this; but this figure needs

further correction to remove the excess estimate for labour costs identified in Section 2. When this is done, the subsidy for research received by universities and university-linked research institutes is reduced, to Yen 935 billion, about 1/3 of the total government subsidy for research. This direct government support to university research is not distributed evenly. National universities receive 81%, public universities, 11%, and private universities, 8%. The reduced subsidy does not represent a reduction in government expenditure: the residual amount, Yen 320 billion, is received by the universities, in effect as a concealed subsidy for teaching and other costs.

14 R. M. Solow, Technical Change and the Aggregate Product Function, *Review of Economics and Statistics*, **39**, 214 (1957); *Growth Theory: An Exposition*, Clarendon Press, Oxford (1970).

15 O.E.C.D., *Technology, Productivity and Creation of Employment*, Volume 2 Analytical Report, O.E.C.D. Paris (1996).

16 J. Minasian, Research and Development, Production Functions and Rates of Return, *American Economic Review*, **59**, 80 (1969); Z. Griliches, Research Expenditures and Growth Accounting in B. R. Williams (ed) *Science and Technology in Economic Growth*, MacMillan, London (1973); N. E. Terleckyi, *Effects of R&D on the Productivity Growth of Industries*, National Planning Association, Washington (1974).

17 A. Goto and K. Suzuki, R&D Capital, Rate of Return on R&D Investment and Spillover of R&D in Japanese Manufacturing Industries, *Review of Economics and Statistics*, **71**, 555 (1989).

18 For references see D. Flath, *The Japanese Economy*, Oxford University Press, NY (2000).

19 O.E.C.D., *Economic Outlook*, **60**, A28 (1996).

20 F. Martin, The Economic Impact of Canadian University R&D, *Research Policy*, **27**, 677 (1998) has used a similar argument to suggest that Canadian universities contributed $Can 15.5 billion to the Canadian economy in 1993 (*i.e.* 2.2% of GDP).

21 K. J. Arrow, Economic Welfare and the Allocation of Resources for Invention" in R. R. Nelson (ed) *The Rate and Direction of Inventive Activity*, 600, National Bureau of Economic Research, Princeton (1962).

22 E. Mansfield, J. Rapoport, A. Romeo, S. Wagner, and G. Beardsley, Social and Private Rates of Return from Industrial Innovations, *Quarterly Journal of Economics*, **71**, 221 (1977); H. Odagiri and N. Murakami, Private and Quasi-Social Rates of Return on Pharmaceutical R&D in Japan, *Research Policy*, **21**, 335 (1992).

23 The R&D reports identify research funds as "basic", "applied" or "development" only for the disciplines of science, engineering, agriculture and medical sciences. A small proportion of these funds is used to support research in the social sciences, humanities, education and the arts: in the universities basic research constitutes 81.5% of the use of these funds. In the absence of direct data, it is assumed that the same proportion of basic research is sustained for the whole of non-science research expenditures. Almost all (90%) non-science research expenditure occurs under the statistical grouping of "Universities and Colleges", two-thirds of it in universities.

24 R. R. Nelson, The Simple Economics of Basic Scientific Research, *J. Political Econ.*, **67**, 297 (1959).

25 N. Rosenberg, Why do Firms do Basic Research (with their own money)? *Research Policy*, **19**, 165 (1990).

26 E. Mansfield, Basic Research and Productivity Increase in Manufacturing, *American Economic Review*, **70**, 863 (1980); *idem*, Industrial R&D in Japan and the United States, *ibid*, AEA Papers, **78**, 223 (1978); A. N. Link, Basic Research and Productivity Increase in Manufacturing, *ibid*, **71**, 1111 (1981); Z. Griliches, Productivity, R&D and Basic Research at the Firm level in the 1970's, *ibid*, **76**, 141 (1986); *idem*, R&D and Productivity in P. Stoneman (ed), *Handbook of the Economics of Innovation and Technological Change*, 52 Blackwell, Oxford (1995); F. R. Lichtenberg and D. Siegel, The impact of R&D investment on Productivity, *Economic Enquiry*, **29**, 203 (1991).

27 The scale of universities' contributions to basic research in Japan tends to obscure a curious anomaly. In the areas of science, engineering, agriculture and medical sciences (the sciences) 52% of university research is classified as "basic"; it follows that almost half of university research in the sciences is either "applied" (41%) or "development" (8%) (figures from R&D report, ref 2). These proportions have been maintained for the past 20 years (Ref 12). Previously, basic research constituted a much higher proportion (75%) of expenditure on the sciences. Consequently, while expenditure on university research in the sciences has doubled in real terms since 1970, the amount classified as "applied" research has quadrupled and basic research funding has increased by only 40%. Part of the explanation may lie in the definitions of the categories of research. Basic research is defined as "research undertaken primarily for the advancement of scientific knowledge, where a specific practical application is indirectly sought"; whereas applied research is "undertaken primarily for the advancement of scientific knowledge, with a specific practical application sought directly" (Ref 2, 12). [Significantly different definitions appear under "Explanation of Terms" in the R&D Survey (Ref 2): "(1) Basic research: Theoretical or experimental research undertaken for the formulation of hypothesis and theories, or for the acquisition of new knowledge, without any particular application or use in view. (2) Applied research: Research undertaken in order to determine possible uses of basic research with a specific practical aim or objective, or to explore a new form of application different from the existing one".] These definitions may make it difficult to categorise much research in engineering, agriculture or medical sciences as "basic" despite its fundamental characteristics. Some part of the explanation for the reduced proportion of basic research may also be found in the tendency of official funding bodies to seek "relevance" in research proposals.

28 E. Mansfield, Academic Research and Industrial Innovation, *Research Policy*, **20**, 1 (1991); **21**, 295 (1992); **26**, 773 (1998).

29 M. Beise and H. Stahl, Public Research and Industrial Innovations in Germany, *Research Policy*, **28**, 397 (1999).

30 E. Mansfield, M. Scwarz and S. Wagner, Imitation Costs and Patents, *Economic Journal*, **91**, 907(1981).

31 R. C. Levin, Appropriability, R&D Spending and Technological Performance, *American Economic Review* (Papers and Proceedings), **78**, 424 (1988); J. I. Bernstein, Costs of Production, Intra- and Inter-industry R&D Spillovers, *Canadian J. Economics*, **21**, 324 (1988); W. M. Cohen and D. A. Levinthall, Innovation and Learning, *Economic Journal*, **99**, 569 (1989).

32 Research costs for universities and for research institutes linked to universities are taken from Table 1; for companies and research institutes, costs and numbers of regular researchers are taken from the R&D Report, Ref 2. For universities, unit costs are calculated on the basis of numbers of university teachers; figures given for the number of regular researchers in universities in the R&D Report include graduate students and hospital staff. If these are included, the average unit cost is reduced to Yen 8 million; if it is assumed that of these, only the university teachers have an fte of 0.5, then the average cost becomes Yen 11.7 million. Removal of the evident difference between unit costs for research in companies and universities indicated in the statistics would presumably be welcomed officially for removing the embarrassment of apparent gross under-funding of university research.

33 Institute for Science Information, *National Science Indicators on Diskette, 1981-1996*, Institute for Scientific Information Inc., Philadelphia.

34 K. J. Morgan, *Survey on Research, 1997*, RIHE. The importance of using a broad definition of publications is revealed by the differences in the patterns of publications reported for the 3 categories of research institutes. In the commercial institutes 78% of publications are as research reports, 16 % as journal articles, 3% as

seminar and conference papers, 3% as books, and 1% as patents; in governmental research institutes the proportions of research reports, 10%, and articles in journals, 72% are inverted; and in university-linked institutes, these proportions are 10% and 50% respectively with 37% as seminar and conference papers. The distribution of publications in university-linked institutes is generally similar to that in universities. As with the comparable surveys of publications in universities, there is a wide spread of numbers of publications reported by the responding institutes (Ref 5).

35 A similar observation, that the costs of research publications produced in universities and research institutes were similar, except that, in universities, teaching was provided at no additional cost, was derived from an early attempt to identify research costs in British higher education. K. M. Clayton, *The Measurement of Research Expenditure in Higher Education*, School of Environmental Sciences, UEA, Norwich (1987).

36 O. Granstrand, Internationalization of Corporate R&D: a Study of Japanese and Swedish Corporations, *Research Policy*, **28**, 275 (1999).

37 K. Pavitt, What Makes Basic Research Economically Useful?, *ibid*, **20**, 109 (1991)

38 M. Kenney and R. Florida, The Organization and Geography of Japanese R&D, *ibid*, **23**, 305 (1994).

39 P. Patel and K. Pavitt, Patterns of Technological Activity in P. Stoneman,. *Handbook of the Economics of Innovation and Technological Change*, Blackwell, Oxford (1995); J. I. Bernstein and X. Yan, International R&D Spillovers between Canadian and Japanese Industries, *Canadian J. Economics*, **30**, 276 (1997).

40 F. Narin, K. Hamilton and D. Olivastro, The Increasing Linkage between US Technology and Public Science, *Research Policy*, **26**, 317 (1997)

41 An assumption of an economically effective lifetime for academic research does not imply a similarly restricted life for its intellectual content. The intellectual value of the "invention" of logarithms, the calculus, or the genetic code continues. A short economic life merely reflects the rapid erosion of economic value by the need to discount returns over time. Receipt of Yen 100 in 50 year's time is currently worth Yen 5 if the rate of interest is 6%.

42 For R&D in Japanese pharmaceutical industry in the period 1967-1986, rates of return are estimated to be: private, 15% - 19%; quasi-social, 20% - 23%; social, 30% - 43%, H. Odagiri and N. Murakami (ref 22). Recent evaluation of the social benefits from medical research in America have identified huge returns: research that reduced deaths from cancer by 20% would be valued at $10 trillion (double the US national debt), K. Murphy and R. Topel in *Exceptional Returns: the Economic Value of America's Investment in Medical Research*, Funding First, Mary Woodward Lasker Charitable Trust, to be published (2000), (www.fundingfirst.org).

43 T. P. Mamuneas, Spillovers from Publicly Financed R&D Capital in High-Tech Industries, *International J. Industrial Organization*, **17**, 215 (1999)

44 S. L. Mintz and B. Lev, Seeing and Believing, *CFO*, **1999**, February, 29, have devised a simple formula to permit "back of envelope" calculation of the relationship between company knowledge capital (K) and earnings (E) to the return from investment in R&D (R): K = (E/C) = RY, where C is a constant and Y is the knowledge capital yield. The constant, C, is put at 10.5%, equal to the average expected after-tax returns from industries consisting almost entirely of knowledge assets (computer software, biotechnology, pharmaceuticals). Applying this formula to the data for all industry performing R&D in Japan gives a knowledge capital yield of 16.06 (*i.e.* Yen 1 spent on R&D yields Yen 16.06 knowledge capital). By using this factor, it follows that from an expenditure of Yen 1,471 billion on university research (non-tangibles), potential earnings of Yen 2,482 billion would be expected. The agreement between this result and that obtained systematically in the text has to be

seen as fortuitous.

45 Even in the US, companies provide less than 7% of total university research costs (National Science Foundation (NSF), *Science and Engineering Indicators 2000*, NSF Washington (2000). Until recently, any such payments for the national universities in Japan were absorbed into government funds.

46 MESSC, *Japanese Government Policies in Education, Science, Sports and Culture, 1997*, MESSC, (Tokyo), 1998.

47 The list of research institutes included in the R&D survey (ref. 2) is "compiled on the basis of reports from the concerned ministries and agencies". These research institutes (not linked to universities) report expenditure on R&D in social science (7%), and education and other disciplines (3%). Given the large number of financial, economic, social and cultural research institutes in Japan, these percentages appear to be low.

48 It is tempting to regard the role of private universities, which fund about two-thirds of university research in the social sciences, humanities, education and the arts, as a proper response to market forces. While the immediate cause is the high proportion of teaching in these areas by the private universities, this in turn reflects demand for studies in the humanities and social sciences.

49 R. Henderson, A. B. Jaffe and M. Trajtenberg, Universities as a Source of Commercial Technology, *Review of Economics and Statistics*, **80**, 115 (1998).

50 E. M. Berman, The Economic Impact of Industry-Funded University R&D, *Research Policy*, **19**, 349 (1990).

51 D. M. Hicks, P. A. Isard and B. R. Martin, A Morphology of Japanese and European Corporate Research Networks, *Research Policy*, **25**, 359 (1996).

52 Ref. 6. The figure includes both commercial and non-commercial collaborations.

53 P. Dasgupta and P. A. David, Toward a New Economics of Science, *Research Policy*, **23**, 487 (1994).

54 R. R. Nelson, Institutions Supporting Technical Advance in Industry, *American Economic Review*, (Papers and Proceedings), **76**, 181 (1986).

55 I. M. Cockburn and R. M. Henderson, Factors Affecring Productivity in Knowleelge Transfers from Universitics to Pharmacentical Industry, *J. Industrial Economics*, **46**, 157 (1998).

教育の経済（パート6）

－大学研究のコストと利益－

キース　J．モーガン*

過去40年間にわたり，大学研究に費やされる予算は，名目上は年率12パーセントの伸びをみせてきた。しかしながら公表された数字は，総合大学・単科大学・研究所・大学附属病院における，過剰な人件費，かたや貧弱な研究設備費といった経費を一元的にとらえており，実際の経費はあいまいである。

これらの条件や関連する要因を調整すると，大学及び関連施設の研究にかかる実際のコストは1996年には，1.8兆円（対GDP比0.38%）となっている。研究領域の違いによる差異がみられる。10年以上にわたり，研究資本が低下しうるとすれば，1996年度において，大学研究にかかる経費は累積資産6.9兆円に対応している。

豊富なデータにより，研究開発に対する投資は生産性向上の大きな要因であることは確かであり，大学の基礎研究に対する産業界の依存度の高さを示している。基礎研究から得られる大きな成果は，大学研究の効率の相対的な高さと相まって，産業界が民間研究により同様にあげている成果と比較して，社会への貢献度を高める力となっている。日本の産業界全般における民間研究に対するデータを分析すると，平均して年率28パーセントの社会全体への貢献と評価される。経費については，開発と結果をあげるまでに大きな遅れがある場合は，学術研究の成果に対する比率は低くなり，11から16パーセントとなる。この論点にたつと，大学研究は，国民総生産の0.54から0.58パーセントの伸びとなるであろう。

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