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The place of universities in the system of knowledge production

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Abstract

In the last 5 years, some authors have argued that the system of knowledge production has undergone important changes, and have predicted that universities would no longer be the main locus of knowledge production. The present paper shows that though we observe a diversification of the sites of knowledge production, universities remain at the center of the system, while the growth of the other sectors (hospitals, industries and governments laboratories) is strongly linked to universities.

Keywords: University; Knowledge production; Institution

1. Introduction

After having been left out of major government policies centered on industrial innovation, universities seem, over the last 5 years, to have become the object of a renewed interest among students of the system of knowledge production. Instead of focusing only on the importance of R&D activities and knowledge transfer to industries, recent studies reflect on the place of universities in the system of institutions involved in the contemporary knowledge production system (Etzkowitz and Leydesdorff, 1997).

Two tendencies can be observed. The first, represented above all by Gibbons et al. (1994) in their influential book *The New Production of Knowledge*, identifies heterogeneity as an important characteristic of the contemporary landscape of science production. The authors rightly observe that knowledge is no longer produced only in university settings but is also found increasingly in many different loci, like government laboratories, industries and think-tanks and that it tends to be produced in contexts of application. They predict however that in the new mode of production, "the universities, in particular, will comprise only a part, perhaps only a small part, of the knowledge producing sector" (Gibbons et al., 1994, p. 85). Of course their view of the dynamics of university research is only one aspect of a more general model of knowledge production. Our paper concentrates on universities and thus we restrict our comments on them in order to compare the view of Gibbons et al. on these institutions with the data we have produced on university research. As many have observed, the characteristics of Mode 2 are not as recent as they suggest and they also can be tested independently (Pestre, 1997; Weingart, 1997; Godin, 1998). The other tendency, far from suggesting any decline, notes on the contrary the "Enhanced role of the university" (Leydesdorff and Etzkowitz, 1996, p.

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282) and suggest to study the dynamics of the so-called "Triple helix" of the relationships between university, government and industry.

2. Looking for empirical tests

Recent studies have tried to test some of the trends suggested in the literature by using bibliometric data on the growth of nonuniversity research (Godin, 1995; Hicks and Katz, 1996), and confirmed the (noncontroversial) thesis of the diversification of the loci of scientific production, a trend also visible in the diversification of R&D investments. For example, in OECD countries, the share of GERD funded by government has decreased from 40.9% to 34.5% between 1986 and 1995, with industry taking largely the place left by government.

But diversification is one thing and the decline of universities is another and we would like to suggest in this paper that one cannot infer the latter from the former as is implicitly done by Gibbons et al. As we will see, far from declining, university research is stable and even increasing. By analysing the relationships between the components of the knowledge production system in Canada, that is between universities, industries, government laboratories and hospitals, we will show that despite a real diversification of the loci of production, universities still are at the heart of the system and that all other actors rely heavily on their expertise.

After a presentation of the data source and methodology we will present, for the case of Canada, the evolution of the relationships between the components of the knowledge production system and conclude with interpretations as to why it is premature to predict the decline of universities. Though our data are limited to Canada, everything suggests that the trends should be similar in other countries as well.

3. Source of data

The Canadian Bibliographic database covers the years 1980 to 1997. It has been constructed from the CD-ROM editions of the Science Citation Index (SCI). All documents containing a Canadian address have been retained, cleaned for harmonisation of the addresses and codified according to sectors from which the paper originates. Though the SCI surveys 14 types of documents published in scientific journals, the present analysis is based on the three types that best reflect the production of new scientific knowledge: articles, reviews and notes. Together, these items make up 90% of all documents that appear in scientific journals surveyed by the SCI. With this definition, Canada produces about 4% of the world's scientific production.

Documents were then classified by subject area, using the classification system developed by Computer Horizon (CHI). CHI's system, unlike the SCI's, never places a journal in more than one subject area, thus avoiding double counting. The classification includes eight major subject areas which are divided into more than 100 specialities.

Since we are primarily interested in studying the relationships between sectors, we have attributed each paper to one or many of the following four sectors using the institutional addresses of the authors: university, industry, government (federal and provincial) and hospital. A publication is thus assigned to each sector represented in the addresses. There is also an "other" category, which includes not-for-profit organisations, museums and other college-level institutions. Though most hospitals are affiliated to universities, we found useful to distinguish them from these institutions when authors include hospital address.

4. Method of calculation

We want to measure the *presence* of universities in the system of knowledge production, that is the participation of at least one university in a given paper. In the past, there has been a lot of discussion about the proper way to calculate the contribution of each participant institution. The debate opposed the partisans of fractional counting to those of integer counting. [1] In the first, the papers are fractionally attributed to each of the participating institutions an

[1] For details on this debate, see the special issue of *Scientometrics* 20 (2)(1991), and the exchange in *Science and Public Policy* 15 (1988) 149–161.

percentages are calculated on the total number of papers while in the second, each institution is attributed one paper and the percentages are calculated on a corrected total that takes into account multiple counting. Given that we want to measure the *presence* of universities in the system of knowledge production, we use the latter method but we calculate percentages on the total number of papers.

Before looking specifically at universities, let us first have a quick look at the diversification of the Canadian system of knowledge production.

5. Diversification of research

In 1995, the university sector is present in 81.9% of the 25,666 papers containing at least one Canadian address (hereafter called" Canadian papers" for the sake of brevity) (Table 1). The government sectors are present in 16.5%, followed by the hospital sector (12.8%) and industry (4.6%). For the period 1980–1995, the presence of sectors other than universities has increased from 37.3% to 38.4% of the total number of Canadian papers. This corresponds to a 68% growth in the number of papers containing a nonuniversity address over the period compared to 63% for the growth in the total number of papers. The fastest growing sector has been industries with 100.2%, followed by hospitals with a 73.6% increase, and government laboratories with 48.6%. Research has indeed diversified over the period, but given this diversification of the type of institutions and the growth of collaborative papers, two things can happen if the growth comes from nonuniversity research: (1) if the research is done independently of the universities, it will imply a decline of the proportion of university papers as predicted by Gibbons et al., or (2) if it is done in collaboration with them, the presence of universities will not necessarily diminish and its proportion will depend on the level of collaborations between sectors. As we will now see, it is the second possibility which corresponds to reality.

6. The growth of university research

Table 1 shows that the presence of universities in scientific papers has increased from 75.0% in 1980 to 81.9% in 1995 (see Fig. 1). Data for UK also shows that the percentage papers with at least one university address increased from 59.2% of the total in 1981 to 64.3% in 1994 (Hicks and Katz, 1997, 5). Recall that this indicator is based on the *presence* of at least one university address in a paper and is computed on the total number of papers.

These data clearly suggest that the real effect of the diversification has thus been to further stimulate university research through collaboration and not to diminish their presence in the system of research. A look at the evolution of intersectorial collaboration will confirm this analysis.

Table 1
Breakdown of Canadian papers by sectors

	1980	1985	1990	1995
University				
N	11,838	15,218	18,153	21,008
Percentage	75.0%	76.7%	79.7%	81.9%
Hospital				
N	1896	2418	2824	3293
Percentage	12.0%	12.2%	12.4%	12.8%
Federal government				
N	2453	2970	3216	3357
Percentage	15.6%	15.0%	14.1%	13.1%
Provincial government				
N	388	551	737	864
Percentage	2.5%	2.8%	3.2%	3.4%
Industry				
N	595	847	951	1191
Percentage	3.8%	4.3%	4.2%	4.6%
Others				
N	554	791	954	1172
Percentage	3.5%	4.0%	4.2%	4.6%
Total (multiple count)	17,724	22,795	26,835	30,885
Total (number of papers)	15,774	19,850	22,774	25,666

7. Intersectorial collaborations

We measure institutional collaborations between sectors using addresses of authors in multi-addressed papers. The presence of at least one address of a

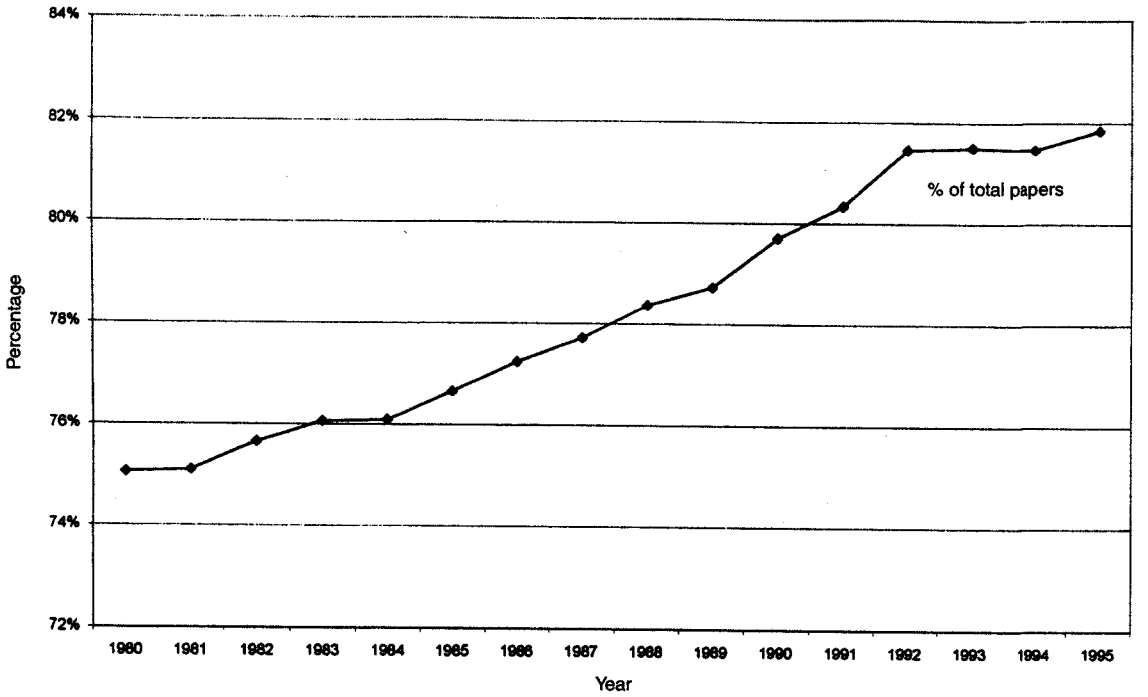

Fig. 1. Share of Canadian universities papers.

university and at least one address of a private firm is thus counted as a university–industry collaboration. As shown in Table 2, the scientific collaborations of universities with industries, hospitals and government laboratories have increased by 155% from 1980 to 1995. It went from 14.6% of papers with at least a university address in 1980 to 21% in 1995. In the latter year, almost half of the collaborators are hospitals, followed by federal laboratories (23.3%), industries (10.6%) and provincial laboratories (9.2%).

Intersectorial collaborations of universities vary, of course, according to disciplines. For the year 1995, 33.2% of university papers in the field of clinical medicine were written in collaboration. This field also accounts for more than 50% of all intersectorial collaborations of universities. It is followed by biology (21.8%), biomedical research (20.5%), earth and space (20.2%), engineering and technology (16.2%), physics (9.8%), chemistry (6.8%), mathematics (2.6%).

If we look at collaborations from the point of view of the different sectors, we find that, in 1980, 31.5% of their papers were written with universities, whereas, in 1995, that proportion grew to 49%. As shown in Table 3, the proportion of the papers written in collaboration with universities grows regularly over the period. Except for the hospital sector,

Table 2
Collaboration of universities with other sectors

	1980	1985	1990	1995
Hospital (%)	8.3	9.3	9.4	10.3
Government (%)	4.2	5.1	6.8	7.4
Industry (%)	1.1	1.5	2.1	2.4
Total (%)	14.6	17.1	19.2	21.0

Table 3
Collaboration of sectors with universities

	1980	1985	1990	1995
Hospital (%)	51.5	58.5	60.5	65.8
Government (%)	17.5	21.8	31.0	36.8
Industry (%)	21.6	26.3	40.2	42.5
Total (%)	31.5	36.6	43.8	48.9

which was already strongly linked with universities and has a stable relationship, the other sectors doubled the percentage of their papers written in collaboration with universities, thus strengthening their coupling with them. This trend confirms our thesis that the diversification of research activities outside universities is done in relation with them and thus contributes to their development.

8. Conclusion

Using the concept of presence, that is, the participation of a sector to the total number of scientific papers published in a given country, we have shown that despite a real diversification of loci of production, the presence of universities in the production of scientific research does not diminish in time. This is explained essentially by the fact that these new actors in the system of scientific production produce a large proportion of their papers in collaboration with universities.

We have also shown that over a period of 15 years, each sector (except hospitals) doubled its collaboration with universities thus increasing its links with higher education institutions. Universities are thus more than ever at the heart of the system of knowledge production. Fig. 2 shows the level of collaboration of the different sectors with universities for the year 1995.

In the past two decades, governments have emphasised the need for stronger ties between the universities and the rest of society, especially business. Consequently, policies have promoted university–industry relationships, and have developed strategic programs devoted to thematic research. These programs and policies, which included economic incentives, certainly explain a large part of the trend toward stronger links between universities–industries, and governments–laboratories (Gingras et al., 1999).

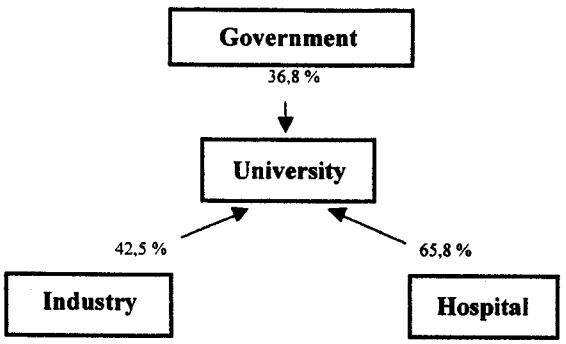

Fig. 2. Share of sectors' papers written with universities (1995).

The regular growth of the links between industry and universities observed in Table 3 is also consistent with recent studies suggesting that firms tend to use universities to contribute to their R&D programs because this is a more flexible way to do research than having their own research infrastructure (Slaughter and Leslie, 1997). Big firms, even those with their own laboratories, as well as small and medium-size companies, can find it more expedient to collaborate with universities thus indirectly transferring part of their costs to the state which is in fact the main source of university funding.

Thus, far from receding from its central place, as suggested by Gibbons et al. (1994), universities have been able to stay at the center of the knowledge production system by using collaboration mechanisms. One could argue that our analysis is based on formal collaborations in journals surveyed by the SCI and that this database does not necessarily reflect the tendency toward application-oriented research produced by collaborations. But since we observe a *growth* of university presence and not a *stagnation* or *decline*, and since this database also shows a growing presence of industries among knowledge producers, it seems more likely that it still reflects the present system of knowledge production in which actors tend to maximise their visibility by publishing their results in the best journals. Everything thus suggests that the study of the changing relationships between universities, industries and governments points towards stronger interactions between components of the system rather than toward the marginalization of any one of the actors involved in the knowledge production system.

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