Should Research Universities be Led by Top Researchers?

Part 1: Are they?

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Abstract

If the best universities in the world – who have the widest choice of candidates – systematically appoint top researchers as their vice chancellors and presidents, is this one form of evidence that, on average, better researchers make better leaders? This paper addresses the first part of the question: are they currently appointing distinguished researchers? The study documents a positive correlation between the lifetime citations of a university's president and the position of that university in a world ranking. The lifetime citations are counted by hand of the leaders of the top 100 universities identified by the Institute of Higher Education at Shanghai Jiao Tong University in their 'Academic Ranking of World Universities' (2004). These numbers are then normalised by adjusting for the different citation conventions across academic disciplines. The results are not driven by outliers. This paper posits the theory that there are two central components involved in leading research universities: managerial expertise and inherent knowledge. It is suggested here that active and successful researchers may have greater inherent knowledge about the academy that in turn informs their role as leader.

Key words: leadership, university presidents, citations, world university rankings.

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1. Introduction

This paper forms Part 1 of a study of universities and those who lead them. It appears to be the first of its kind. Although there is a large academic literature on leadership, there has been little statistical thinking about presidents of universities[2].

The paper is interested in the question: should research universities be led by top researchers? This is a subtle and difficult question. It is explored empirically by examining what the world's universities actually do. If the best universities – who arguably have the widest choice of candidates – systematically appoint top researchers as their presidents, this could be one form of evidence that, on average, better researchers may make better presidents. Economists would call this a revealed preference argument.

When looking at the individuals who lead the world's top 100 universities it is possible to find both a handful of Nobel Prize winners and a handful of leaders with few or no research citations. It might be thought from this fact that there is no systematic link between research output and university leadership. Yet there is a pattern. This paper uncovers a powerful correlation between the research background of a leader and the position of their university in a world league table.

Why is this question important?

First, around the world, interest in university leadership and governance has grown as universities have become increasingly competitive and global. Major changes have taken place in universities and subsequently in the role and responsibilities of its leaders. (These have been widely documented in Barge et al 2000, Barnett 2000, Shattock 2003, Bok 2003, Tierney 2004, Chait et al, 2005, among others). Today's president requires knowledge of entrepreneurialism and fundraising whilst resisting accusations of over commercialisation; they must balance pressures from governing boards and governments to become more managerial on the one hand, whilst being sensitive to faculty demands for collegiality and intellectual freedom on the other. And as science has become ever more costly, long-term strategic planning about research and curricula priorities has become a central and often controversial focus for presidents. It is therefore important to continue to understand successful leadership in these times.

Second, given the centrality of research performance in many university mission statements – expressed through the quality of research produced, the research eminence of its staff and the concomitant income they generate – it seems a logical step to turn to the research background of their presidents. The first question, addressed in this paper through statistical tests using Pearson's correlation coefficient and Spearman's rho, is to ask whether the world's top universities currently appoint top researchers to the position of president. If it is found that they do, it will be important to understand why. Could it be that committed researchers have a greater appreciation of

[2] President is used here to denote the executive leader of a university. The term is used to include principal, vice chancellor, rector among others.

academic culture that in turn informs strategic thinking? Or is the issue one of receiving respect from colleagues, explained in the words of a former Harvard Dean - 'Being a competent researcher myself made it possible for me to look a Pulitzer or Nobel Prize Winner in the eye' (Jeremy Knowles, interview 2005). Are there times in a university's development when it may require a researcher over a non-researcher? These possible interpretations and others are further discussed after the results are presented later in this paper.

Finally, the emphasis in this study is on the top research universities. This group has been chosen because it is important to understand the actions of successful organisations. But it is also significant to note that the majority of these universities are based in the United States. Much has been talked of in the press about issues of brain-drain (see for example Time Magazine, March 15, 2005) as faculty from Europe, Asia and beyond head for the US. Given the importance of universities to an economy, if many top academics leave their home country this must be a cause for concern.

The importance of research universities is currently receiving attention in Europe. The European Parliament has created the Lisbon Agenda outlining goals 'to make the European Union the most competitive and dynamic knowledge-driven economy by 2010" (European Parliament March 2002). In Germany the governing Social Democratic Party has recently announced that they are to spend 1.9 billion Euros to develop 10 elite universities that 'can compete with the world's best' (April 9 2005, DW-World.de). Universities themselves have started to acknowledge that their position has declined comparative to the US. In 2002 a group of top universities in Europe founded the League of European Research Universities (LERU). On their website it states 'LERU acknowledges that Europe has lost its pre-eminent position in basic research'.

Hence the focus in this paper is on the top research universities in the world because of what we can learn from them.

2. Research process

This paper focuses on one set of variables or characteristics, namely the lifetime citations of presidents. This score is used here as a measure of how research-active and successful a president has been in his or her academic career. The lifetime citation score of presidents has been normalised in this study to adjust for different disciplinary conventions.

Two rankings of world universities are used. The first is the top-100 universities that have been ranked by the Institute of Higher Education at Shanghai Jiao Tong University in their 'Academic Ranking of World Universities' (2004). (See Appendix 1 for the full list of 100 universities). The second measure of university performance is one based solely on the number of highly cited faculty in each institution.

2.1 Citations

Citations are references to authors in other academic papers as acknowledgement of their contribution to a specific research area. A citation index holds information on cited references from the thousands of academic journals and monographs published each year. These identify the source or sources of a fact or finding or idea, and also other research in the same area. Citation information used in this study comes from the Web of Science, an on-line database comprising of the Science Citation Index, Social Science Citation Index and the Arts and Humanities Citation Index. These indices, which are now owned by Thomson Publishing (ISI), are the most commonly used by the global academic community.

Data on the 100 presidents were collected between October and December 2004. Only those presidents in post during this period are included. Biographical information came from university web sites, though direct requests for CVs were made on occasion. Each president's lifetime citations have been counted by hand.

Most important when using citations as any kind of measure is recognition of the huge differences between disciplines. For example, a highly cited social scientist might have a lifetime citation score of around 5,000 whereas a molecular biologist could have a score over 20,000. Bibliometric indicators have been used more consistently across the sciences than in the humanities and social sciences. Such use is most evident in the natural and life sciences, though less so in engineering and the behavioural sciences (van Raan 2003). These disciplines publish more journal articles and have a higher prevalence of co-authorship.

The social sciences are patchier. For example, economics relies heavily on journal articles though, unlike the science publications that tend to publish quickly, in economics it can take up to two years from acceptance for publication for a journal article to appear (Hamermesh 1994). Writing articles for journals is less common in the arts and humanities. These disciplines tend more towards publishing monographs. Cronin et al (1997) found that in the discipline of sociology two distinct groups of highly cited academics co-existed - those highly cited through journal articles and those through monographs. This should not present a problem here because citations from both books and journals have been counted.

ISI has created a 'Highly Cited' (ISI HiCi) category that identifies approximately the top 250-300 academic researchers (depending on discipline) across 21 broad subject areas over the last two decades (1981 – 2002). They are dominated by science subjects, totalling 19. The social sciences are also covered, but there are only two social science subject areas, namely 'Economics and Business' and 'Social Sciences - General'. There is currently no 'Highly Cited' category for authors in the arts or humanities[3].

The discrepancies in citation levels across disciplines are demonstrated in the number of new cited references that appear in ISI every week. The sciences generate approximately 350,000 new cited references weekly, the social sciences 50,000 and the humanities 15,000.

Using citation thresholds produced by ISI HiCi a normalised citation score has been produced in this paper for 23 subject areas (see Appendix 2). These include a score for the humanities that has been generated for the purposes of this study. It is important to note that the discipline of law is classified in ISI as being in the social sciences not the humanities. It is included here in the 'Social Sciences - General' category.

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[3] ISI HiCi is available at www.isihighlycited.com

In this paper, each university president is assigned a normalised citation score, which reflects both the differences across disciplines and their personal citation levels. This score is referred to as the *'P-score' = president's individual lifetime citation score normalised for discipline*. The P-score has been generated by using a scale produced by ISI HiCi. It has been used here as an exchange rate normalising the different citation conventions across disciplines. Each president's lifetime citation score has then been divided by their subject score. The normalised P-score produced through this process makes it possible to do like-for-like comparisons between those from different disciplines (see Appendix 2).

Substantial effort has been made to try to accurately assign citation numbers to people's names. However, some measurement error must be presumed. This is likely to make it harder to find significant correlations.

Van Raan (1998, 2003, 2005) has raised areas for concern when using citations as measures of quality. He suggests that citation indices have become easy tools for policy makers and university administrators keen to make quick assessments of individual research output and quality (2005). Wouters (1999) points out that the ISI system was designed to retrieve information not evaluate it. Other problems include discrepancies in matching people with papers, especially when there are co-authors involved (van Raan 2005). Also, self-citing is a potential problem that can take two forms: first, over-citing one's own work in academic papers and second, self-citation in journals to try to raise the journal impact factor. The impact factor is a measure of how often a journal gets cited. An example of this is discussed in the British Journal of Anaesthesia by Fassoulaki et al (2000), where they report a significant correlation between self-citation levels and journal impact scores in the 1995 and 1996 issues of six anaesthesia journals.

Other possible difficulties with citations include inconsistencies in methods of referencing, and inaccuracies in citation statistics (Moed 2002, King 2004). Finally, monopoly concerns have been raised about over-reliance on Thomson's citation index (Weingart 2003, 2004).

Although van Raan (2005) notes the weaknesses of bibliometric measures, he also argues that citations are a good indicator of performance over long periods of time. His preference for evaluating science is to couple peer review with bibliometric analysis.

There have been a number of studies comparing the UK's Research Assessment Exercise (RAE) results with bibliometric measures. Oppenheim (1997) used ISI data to compare 1992 RAE results with citation indicators in three subject areas: anatomy, genetics and archaeology. He finds a strong correlation between the two methods of assessment and notes that in archaeology there is a greater reliance on monographic literature. Norris and Oppenheim (2003) replicate this study with the same results following the 2001 RAE[4]. Smith and Eysenck (2002) discover a similar correlation across all UK psychology departments in the 2001 RAE. These authors advocate the replacement of RAE with citation indicators.

[4] As noted by Sharp (2004), the RAE methodology used in 1992 was the same, with small changes, in 2001.

Language biases have been shown to exist within ISI (van Leeuwen et al 2001) though it is now considered to be less of a problem because most journals publish in English (King 2004). King suggests that preferential referencing may take place in the US (i.e. that Americans are more likely to reference Americans) partially a feature of the size of that nation's output. To try to circumvent this, separate analyses of US data are offered below.

2.2 League tables

As higher education has become global, in the recruitment of international students and staff, so have league tables. International tables existed for a number of years in areas such as business education through the Financial Times. But in 2003 the first global league table of universities was produced by the Institute of Education in Shanghai at Jiao Tong University (SJTU). SJTU used a process of inviting comment through their website to make adjustments to their methodology for the 2004 table.

An advantage of the SJTU table is that it is not produced by a newspaper or magazine. Media-generated university league tables are ubiquitous and controversial. Tables, such as those in The Times in the UK, and US News and World Report in the US, offer information to potential students across a range of criteria. Media-driven league tables may be useful heuristic devices for students but as objective tools of assessment of university quality they are unreliable.

The main criticism against them is that they are produced by commercial organisations designed to make money by selling their publications. Therefore a headline is required. To generate a story, the methodology is changed, often annually, which ensures that institutions at the top rotate (Lombardi et al 2002). Lombardi and colleagues suggest instead that in the US, university positions actually change very little each year if a fixed method of analysis is used (2002).

The Center for Studies in the Humanities and Social Sciences ('*TheCenter*') was created as a non-profit organisation in 1998 in the United States. Its mission is to develop methods for measuring and improving university performance. For a number of years *TheCenter* has produced an alternative ranking, 'The Top American Research Universities' (Lombardi et al 2003).

This ranking differs from media equivalents because actual numbered positions are not assigned. Instead universities are assessed on nine separate measures. Those that score highly in at least one of the nine measures are put into a 1-25 top research university category. The measures include: total research, federal research, endowment assets, annual giving, national academy members, faculty awards, doctorates granted, postdoctoral appointees and SAT scores.

Some degree of ranking does exist because they are ordered depending on the number of points they score across the nine categories. So the top three universities score 9 out of 9, the next six universities score 8 out of 9, and so on[5]. In the last publication of 'The Top American Research Universities' (2003) there were 52 universities that appeared at least once in a top-25 category.

[5] The full table can be found at www.thecenter.ufl.edu.

The measures of university quality used in both *TheCenter* and the SJTU world league tables do not exactly correspond. However, it is interesting to compare the number of US universities at the top in both tables. *TheCenter*'s top-25 category has 52 universities included. Of these, 44 also feature in the SJTU global table. Positions 1-27 are exactly correlated in both rankings. In other words, these two rankings of top US universities are very similar.

The SJTU 'Academic Ranking of World Universities' (2004) world league table uses 6 different criteria to assess universities. The table below comes from the SJTU web site:

Criteria	Indicator	Code	Weight
Quality of Education	Alumni of an institution winning Nobel Prizes and Fields Medals	Alumni	10%
Quality of Faculty	Staff of an institution winning Nobel Prizes and Fields Medals	Award	20%
	Highly cited researchers in 21 broad subject categories	HiCi	20%
Research Output	Articles published in Nature and Science*	N&S	20%
	Articles in Science Citation Index-expanded and Social Science Citation Index	SCI	20%
Size of Institution	Academic performance with respect to the size of an institution	Size	10%
Total			100%

* For institutions specialized in humanities and social sciences such as London School of Economics, N&S is not considered, and the weight of N&S is relocated to other indicators.

There are, arguably, weaknesses in the SJTU methodology. First, younger universities stand to lose out; particularly in the first category that assigns weight (10%) to alumni awards. Second, the humanities and the social sciences are weakly represented here – though SJTU have done some adjustment for this. There are no HiCi's in the arts and humanities and far fewer in the social sciences. The Awards category is also limited. Nobel Prizes are only given for achievement in physics, chemistry, medicine/physiology, economics, literature and peace, and Fields Medals only for mathematics.

King (2004) suggests that citations are the most reliable measure of research quality and output. In a feature in the journal 'Nature', King uses the ISI citation index to measure the quantity and quality of science across different nations (2004). Van Raan (2005) is more hostile.

There are three reasons why the SJTU league table has been chosen for this study as a measure of research university success. First, the table is not produced by a commercial publication, nor is it media-driven. Second, though the methodology has weaknesses (as identified above), it is the most robust currently available for the world as a whole. Third, a second non-media league table - 'The top American Research Universities' - has been used as a comparator for US universities who make up the largest group. A high level of cross-over exists between the two tables. In other words, they produce similar rankings.

A further measure of university performance is used in this paper, one that draws on the ISI citation data. Each of the 100 universities has some Highly Cited faculty. These numbers are totalled for each institution and then correlated with the president's P-score. As has been mentioned above, the HiCi category excludes arts and humanities faculty, but this bias is likely to be similar across most universities.

The highest number of HiCi's in one university is 158 at Harvard. Across the 100 institutions the mean is 23. As can be seen later in Figure 12, the US institutions tend to have much higher numbers of HiCi's. It is important to note that there may be a slight US bias built into the HiCi process that is a reflection of a possible US bias in general in citations data. As mentioned above, this is likely due to the size of the US research community in terms of faculty and journals. Also, a considerable number of top academics from Europe and around the world have been attracted to the US, whose universities are better resourced and can often pay higher salaries - a point that King notes (2004). Hence, a percentage of the US HiCi's are not of US origin.

However, using the HiCi category has some validity as a measure on its own. First, though size of university may make some difference, it does not necessarily. For example, some of the smallest universities have the largest number of Highly Cited faculty. The California Institute of Technology has a student population of 2215 with a HiCi total of 56[6], whereas the University of Wisconsin, Madison, has a student population of 41,588 with HiCi faculty numbering 42. Both are in the top 20 of the SJTU table. In general, when it comes to the number of HiCi's in an institution, size is not a major determinant.

Second, using a measure that counts the number of top faculty in most fields (outside of the arts and humanities) in each institution seems a fair and consistent method of judging the quality of a research university.

Third, the SJTU world league table includes 'alumni awards' as a factor, which immediately discriminates against younger universities. That is not the case with the number of HiCi's. For example, Oxford University has a relatively small number of institutional HiCi's (29) when compared with other universities in the world top 20, where all other universities, except for Tokyo and Cambridge, have in excess of 40. Oxford's age is undoubtedly giving it an advantage in the global ranking, whereas UC San Diego, which has had relatively recent success as a top university and scores very poorly on alumni, has 57 institutional HiCi's, the sixth highest number within the100 universities.

[6] HiCi figures used here date from October 2004.

2.3 Data on the 100 university presidents

It is important to note that the world league table ranks institutions by assigning points (as per criteria above). This can result in two or more institutions being given the same position (see the full list in Appendix 1).

The universities in the top-100 table are dominated by the United States, where 51 of the institutions are located. As can be seen in Figure 1, US institutions are unevenly spread across the world's top 100, dominating the top 20 with 17 universities, and with 30 in the top 40. Of the100 total, only 4 in the bottom 20 are US-based. If we treat American states as individual nations, California, with a population of 36 million, has the highest number of leading universities. Ten Californian institutions are within the top 55; 6 of these are in the top 20, and 7 of the 10 are public or state universities.

Thirty-seven institutions out of 100 are located in European countries. Of these, 11 are in the United Kingdom, 7 in Germany, 4 in both France and Sweden, 3 in Switzerland, 2 in the Netherlands, and 1 each in Austria, Denmark, Finland, Norway, Italy and Russia.

Finally, among the top 100 there are 12 universities in the rest of the world – 5 in Japan, 4 in Canada, 2 in Australia, and 1 in Israel.

The nation location of an institution is not always reflected in the nationality of its president. For example, the top 10 universities are found in two countries – US (8) and UK (2), whereas the leaders come from four - Canada, New Zealand, UK, and the US.

There are 15 female presidents in the sample. There are 6 are in the top 20 universities; 10 are within the top 50. North America dominates with 9 US female presidents and 2 in Canada. The remaining four are in Denmark, France, Sweden and the UK.

Every president in the group of 100 universities has a PhD. They have all been academics, though two spent most of their careers in non-research positions in industry or government, and a small group went almost directly into academic administration.

The age of a president potentially affects his or her lifetime citation levels. The older they are, the greater the opportunity to accrue citations. It is therefore necessary to check whether presidents with the highest levels of lifetime citations are in fact older than those with fewer citations. Finding the age of a president is more difficult today than years ago. Some European universities still publish date of birth information, though they are in the minority. Date of birth can be loosely calculated by using individuals' age at graduation from first degree[7]. Using this method it is possible to compare the ages of presidents at the top and bottom of the top-100 global league table. If it is shown that the top presidents are markedly older than those in the bottom 20, then adjustment of citation scores would be necessary.

The ages of only 80% of presidents' in the top 20 universities and 80% of presidents in the bottom 20 have been obtained. The mean age of presidents in the top 20 universities is 58 years. In the bottom 20 category the mean age of president is 60.

[7] It is important to note that some may have graduated at a younger age and some at an older age.

Because of the closeness in age between these two groups, and in particular the slightly older average age of the lowest quartile, citation scores have not been adjusted.

Figure 2 displays the disciplinary background of the presidents. What is noticeable is the evenness of disciplinary spread across each quintile. Of the 100 presidents, 52 have a scientific background. The scientists are dominated by the life sciences at 50%, but there are also 11 engineers, 6 physicists, 5 chemists and 4 computer scientists.

Thirty-seven of the 100 presidents are social scientists. The largest disciplinary group among the social scientists is that of lawyers, who number 15. Within a second group of 16 there is an even spread of educationalists, political scientists, sociologists and those from public and social policy. Finally, there are 6 economists.

Eleven presidents are from the arts and humanities. This group is noticeably smaller. Taylor (1986) documented the disciplinary distribution amongst vice chancellors and principals in the UK in 1986. He also cites earlier work by Collison and Millen (1969) who showed that in the UK between 1935 and 1967 the proportion of presidents from the arts declined from 68% to 48% while scientists rose from 19% to 41%. Taylor then reports his own findings, that by 1981 67% of vice chancellors and principals were scientists, 13% from the social sciences and less than 20% were from the arts. Cohen and March (1974) showed a similar pattern - in the number of presidents from the arts - for the US between 1924 and 1969.

In an innovative study by Dolton and Ma (2001) on CEO Pay, the disciplinary backgrounds of UK vice chancellors are reported. Drawn from a wide cross-section of British universities (including Oxbridge, civic universities, former colleges of advanced technology, 'new' universities established in the 60s, former polytechnics, schools of technology, business and medicine, and arts and performing arts colleges), they note that VCs in position in 1999 included 3.45% lawyers, 12.64% engineers, scientists made up 25.29%, social sciences including business 35.63% and finally VCs from the arts and humanities made up 12.65%. 10.34% were reported as being non-academics.

Of the 100 presidents in the current paper's sample, 12 are ISI Highly Cited (HiCi) academics. These individuals are more common in the top universities. Of the 12 presidents in HiCi, 6 are in the top 20 group of universities, 3 in the next 20, 2 in the next and 1 in the fourth quartile. Finally there are 3 Nobel Prize winners among the presidents (all in medicine) – two in the top 20 and one in the 20-40 category.

The distribution of citations across the 100 presidents fits Lotka's Law, an application that is often used in bibliometric research. Lotka (1926) describes the frequency of publication by authors in a given field. As can be observed in Figure 3 using presidents' P-scores, a version of this law applies here. Lotka's power law predicts that of all the authors in a specific field, approximately 60 percent will publish just one article, 15 percent will have two publications, 7 percent of authors will publish three pieces, and so on (Potter 1988). According to Lotka's Law of scientific productivity, only 6 percent of the authors in a field will produce more than 10 articles[8]. This law is most accurate when applied over long periods of time and to large bodies of work – for example individuals' lifetime citations.

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[8] The number making n contributions is about $1/n^2$ of those making one.

3. The results

As outlined above, the 100 presidents' lifetime citations are represented by a normalised P-score.

The individual citation scores of the 100 presidents, before adjustment, range from 0 to 28,718. The mean citation score is 2731 and the median is 371. After adjusting for discipline, the highest P-score is 37 points and the lowest is 0. The mean P-score is 6.03 and the median is 2.27. When the group of 100 is split into two, the top 50 universities have a mean P-score of 8.76 and a median of 4.57, and the bottom half of universities have a mean P-score of 3.30 and a median of 0.93. Of the total group of 100 presidents, only 4 have a citation score of zero.

The results are presented here in scatter plots and cross tabulations. In the latter the data are usually grouped into quintiles. Where quintiles are used for 'university rank' (position in global league table), the '1-20' group always refers to the top of the SJTU table. So 1 always equals Harvard.

The most highly ranked universities have leaders who are more highly cited. Figure 4 shows this. It gives a cross-sectional breakdown of P-score by university rank in quintiles. This shows a monotonic decline in citation levels as the universities go down in rank.

The next step is to try to establish statistical significance. The paper does this in two ways.

A natural first approach is to test whether the rank ordering of one variable is correlated with the rank order of the second variable. Spearman's rank correlation coefficient is an appropriate measure. The highest P-score is marked 1 and the lowest P-score is marked 100. The actual rank of presidents' P-scores is then tested for a correlation against university rank.

Using these data, Spearman's rho is calculated at 0.378. With 100 observations the associated 5% critical value for a two-tailed test is 0.195, and at 1% it is 0.254, which establishes that the correlation is statistically significant at conventional confidence levels.

A second approach can be seen in Figure 5, which gives the distribution of the 100 individual P-scores by world university rank. Using Pearson's coefficient (r), the degree of linear relationship between the 'rank of university' and 'president's P-score' can be examined. For the data in Figure 5, Pearson's r is 0.345. The 1% critical value on a two-tailed test is 0.254 which means that the relationship is statistically significant[9]. There continues to be a statistically significant relationship when the natural logarithm of P-score is used; this can be seen in Figure 5a[10].

This correlation, between cites and university quality, can also be seen amongst the sub-sample of female presidents, though at 15 the group is small (Figure 6). It is also

[9] It should be noted that there is evidence that the residuals are skewed.
[10] Though not shown here, when president's actual citation scores (i.e. before adjustment) are tested against university rank, Pearson's r is 0.281. The 1% critical value on a two-tailed test for 100 observations is 0.254 which means the correlation also holds before adjustment to P-score.

statistically significant at the 1% level. The disciplinary breakdown of the 15 female presidents is 7 scientists, 7 social scientists and 1 from the humanities. One president is Highly Cited.

US universities make up 51 out of the 100. The mean P-score for this US group is 8.07 with a median score of 4.86, which is higher than the world group mean of 6.03 and median of 2.27. There are 25 scientists, 21 social scientists and 5 in the humanities. Of the 12 Highly Cited presidents in total, 9 are based in US universities, though two of these are non-Americans - 1 is from Canada and 1 from the UK, who is also a Nobel Prize winner.

Figure 7 presents a scatter plot for the sample of US presidents. Again there is a correlation between citation levels and (world) university position. The correlation is significant at the 1% level.

It is useful to note that, in the world, university rank explains only 12% of the variance in leaders' citations. In other words, there are many other explanatory factors that are not being measured here. However, these correlations are significant enough to warrant further investigation and discussion.

Figure 8 is a cross-tabulation of US presidents' P-scores against rank. The top-50 US universities are represented in groups of 10[11]. As can be seen, the gradation downwards is smooth except for columns three and four. There is still a reduction in P-scores as rank decreases.

Is the citation-rank correlation true for universities outside the US?

So far we have identified a strong positive relationship between the citation levels of university presidents and the position of their institution within a ranking of 100 universities. This association exists amongst the 100 presidents in total, the female group, and the 51 US presidents.

The mean citation P-score for presidents in the 49 countries in the rest of the world is 3.91 with a median score of 1.07. This is below the 100-group mean P-score of 6 and it is half the US mean P-score of 8. Therefore US presidents are twice as cited as those in the rest of the world.

In the rest of the world the presidents include 27 scientists, 16 social scientists and 6 in the humanities. There are 3 Highly Cited researchers in the group. Two are from the Netherlands (there are only 2 Dutch universities among the top 100) and one in Germany.

Figure 9 presents the cross-tabulation for non-American universities. Forty-eight universities are represented - 16 per column[12]. As can be seen again, the mean citations fall as rank of university declines. However, if this group is treated individually as in Figure 10, there is no statistically significant correlation between citation levels and position of president across the 49 countries in the rest of the world.

[11] To present the data in this way it was necessary to remove number 51.
[12] To present the data in this way it was necessary to remove number 49.

A different measure of university quality

Finally, Figure 11 provides data on the number of Highly Cited faculty in the 100 universities in this study. The average number of HiCi's in the 100 universities is 23. As suggested above, the number of Highly Cited faculty in each institution can be viewed as an alternative measure of institutional eminence. It also offers another test against presidents' P-scores. In Figure 12, there is a positive correlation between the numbers of HiCi's in each university and the presidents' P-scores, statistically significant at the 1% level. Despite the appearance of Figure 12, the correlation is not due to outliers. Figure 12a shows that when Harvard, with 158 HiCi's, and Stanford, with 124 HiCi's, are removed the correlation is still significant at a 1% level.

These data uncover a strong relationship between the citation levels of a president and the rank of a university in the global league table, and in a second simpler measure of university performance based on the number of Highly Cited faculty in each of the 100 institutions. Those universities that are highest in the table, and in having the greatest number of HiCi faculty, appoint presidents whose citation scores are also highest. US universities dominate the top end of the global table.

As can be seen in the data, one of the differences between the top American universities and non-American universities is that the former choose leaders who are more highly cited.

3.1 Outliers

It is important to ensure that the results from this study have not been unduly influenced by a small number of presidents with extremely high P-scores. To do this, two tests are available. First, we can return to Spearman's rho, which puts an equal weight on each observation instead of assigning continuous values. As has been pointed out above, a statistically significant rank correlation has been established, with a significance level better than 1%.

The second check on outliers is simply to delete the data used from the highest P-scores for the Pearson's test. To do this the top 5% of P-scores, all located within ranges 30 and 40, were withdrawn and the correlation re-tested, with a result of 0.297. With 95 observations the 5% critical value for a two-tailed test is 0.200 and at 1% it is 0.260, so the correlation remains.

4. Possible interpretations

Data on world university rankings have only recently become available. That universities with strongly research-intensive missions should appoint as their presidents men and women with strong citation records does not appear to have been documented in the literature. The data in this paper do not enable judgements to be made about the weight assigned by selection committees to the research records of presidential candidates as distinct, for example, from other criteria such as managerial expertise or entrepreneurship. But the data do suggest that research universities look for candidates who fit institutional missions.

Internationally active researchers lead the world's top universities. On average, the higher the university is in the global ranking, the more highly cited is that institution's president. There are of course exceptions. The two universities from the Netherlands – in positions 39 and 63 - both have presidents who are Highly Cited. And there are top universities led by presidents with few or no citations. However, these cases are in a minority.

These findings show that in at least one area the top universities are making different choices from those lower in the global ranking. What can we learn from this difference? Why do those institutions at the top appoint former researchers to the role of president?

There are a number of possible reasons for the correlation. They include:

4.1 Good researchers make better leaders of research universities.

It has been recognised in the literature that presidents need to learn particular skills to enable them to lead a university (Cohen and March 1974, Rosovsky 1991, Middlehurst 1993, Damrosch 1995, Ramsden 1998, Bargh et al 2000, among others). In the UK an organisation for training academic leaders has recently been established with government funding.

Leading as the 'first among equals' within the collegial culture of a university is also widely addressed in the higher education literature (Berquist 1992, Becher 1993). Cohen and March refer to it as 'leadership in an organised anarchy' (1974). The political nature of presidencies is discussed in Rosenzweig (2001) and modern issues of commercial pressures on universities in Bok (2003).

Whilst the education and career background of academic leaders has attracted some interest (Cohen and March 1974, Bargh at al 2000, Dolton and MA 2001,) little specific attention has been given to the research background of presidents. Yet most university websites make a great deal of the eminence of the president.

It is clear that better researchers will tend to have greater prestige within the hierarchy of the academy, and presidents who are highly cited may, therefore, enjoy credibility and negotiating strength that extends beyond their own discipline. As was mentioned earlier, Jeremy Knowles the former Dean of Harvard's Faculty of Arts and Sciences (from 1991–2002), said that he believed his own research record helped his position as dean because it gave him greater status and therefore negotiating power when dealing with eminent faculty (interview April 12, 2005). This suggests that being a cited researcher is of symbolic importance.

This message was repeated in an interview with Amy Gutmann, President of the University of Pennsylvania, who said that 'being a researcher sends a signal to the faculty that you, the president, share their scholarly values and general understanding of the culture of the academy'. Amy Gutmann believes that having been a researcher herself helps her to create a climate that is supportive to other scholars. Indeed she suggested that the faculty 'would look askance on presidents who were not themselves good academics' (interview April 28, 2005).

Being a successful research academic may also help in attracting faculty, particularly 'stars', to a university, which has become a preoccupation the world over. Having a president who is a distinguished researcher may enhance the appeal of an institution. Patrick Harker, Dean of Wharton, expressed the view that being a researcher and a leader signals that research is being taken seriously. He stated that the most important part of his job as Dean is ‘in the attraction and retention of faculty’ and that being a respected researcher helps in both these areas (interview 9 April, 2005).

Henry Rosovsky (1991, p. 261-270), a former Dean of the Faculty of Arts and Social Sciences at Harvard (from 1973-1984), believes that when it comes to making decisions about teaching and research ‘those with knowledge are entitled to a greater say’. He goes on to suggest that ‘those with expert knowledge are to be found almost entirely among the academic staff’.

Does a reputed researcher then have the most relevant ‘expert knowledge’? A possible reason why former researchers are chosen by leading universities is that there are two components involved in leading a university, namely managerial expertise and inherent knowledge. The former pertains to having knowledge of generic functions such as finance and budgeting, human resource management, corporate governance, and communication skills, among others. Managerial expertise can be learned through experience in managerial roles, such as chair of department, head of a research centre, or in the role of dean, provost or pro-vice chancellor.

Presidents running top universities will have had experience in managerial positions – running large laboratories or as a provost or dean. Experienced managers can also be brought in to perform specialised administrative roles. Thus a former UK university vice chancellor has suggested (in personal correspondence) that what matters is scholarship not just management. We should take management for granted.

The term inherent knowledge is used here to suggest a specific knowledge of, or insight into, academe that is borne out of expertise gained through academic research. It suggests that good researchers bring something else to the role of leader - a perspective and understanding directly linked to their past as a successful scholar.

Inherent knowledge could also be expressed in terms of Polanyi's tacit knowledge (1967) or even in terms of the notion of native speaker insight. John Heilbron, historian and former Vice Chancellor at Berkeley, suggests that those who have had extensive research experience during their academic careers have an advantage as presidents of large universities because they know the culture and territory (personal correspondence).

It is possible that inherent knowledge also helps leaders inform strategy-making. For example, it may be easier to interpret research trends and future intellectual directions. But how easy is it for a highly cited chemist to assess a faculty member from modern languages or discern the future direction of political theory? One possibility is that faculty at the top of their fields can make a fair assessment about the quality of work produced by those in other fields by using the same mechanisms used generally in academia: namely citation indices and peer review. There are some disciplinary differences in assessment conventions, but on the whole they are the same.

Martin and Samels (1997) suggest, as many do, that *academic* leadership is actually driven by the ‘chief academic officer’ who is either a dean or provost. They suggest that it is people in these positions who actually make decisions about the intellectual direction of a university. However, as Rosovsky points out (1991), the senior academic positions are normally appointed by the president. It is unlikely that a subordinate to the president of a research university would survive if they were propagating strategy very different from that of the president's.

It could be argued that the notion of inherent knowledge in leaders can also be applied to other sectors and industries. For example, those who lead consulting firms or partnerships (Patrick Harker, Dean, Wharton, interview April 29, 2005). Similarly, artistic directors who lead major theatre companies, such as the Royal Shakespeare Company, usually have a distinguished directorial past. And it is unlikely that an editor of a major newspaper has not previously been a journalist of some repute.

4.2 Top universities appoint good researchers for reasons relating to external factors (PR, fundraising and alumni relations), because presidents actually assume less of a strategic leadership role in top universities.

It has been said that US presidents in top universities spend less time running a university because they are so intensively involved with fundraising. This is not the place to compare US presidential leadership with European rectors or British vice chancellors. Briefly, however, the American system is unitary with the president at the head of the hierarchy. Though the president reports to a powerful board of trustees, he or she is ultimately in charge, with a role similar to that of a chief executive officer. Senior academic administrators in the US (deans, provosts, chairs of departments) are normally appointed not voted into position by faculty. In short, the US presidential system is recognised as giving greater authority and powers to university leaders when compared to other systems of higher education from Europe to Japan (Rosovsky 1991, Bargh et al 2000). This is particularly true of US private universities. US publics on the other hand are more exposed to state government intervention.

Amy Gutmann, President of University of Pennsylvania, was clear in an interview that she is centrally involved both in making senior appointments and in deciding the overall strategic direction of the university. Long term strategy is designed through a collaborative process involving the president, and the deans and provosts that she appoints and whose work she oversees (April 28 2005).

There is currently much discussion in the UK about vice chancellors assuming a role more akin to an American president (through editorials in publications such as Times Higher Education Supplement). The new head of the merged University of Manchester has the title President and Vice Chancellor. It is possible that over the next few years we will see more heads of UK universities designated as 'president'.

Another factor that may influence the choice of president in US universities is the academic nature of the appointment. For example, all new presidents must become tenured professors located within an academic department. If a university is proposing to appoint a very weak chemist to the position of president, yet the chemistry department at the appointing university prides itself as being among the best, this could cause problems for selection committees. It is unlikely, however, that this would be a deciding factor in making appointments to the top job. In this type of situation it would be usual for a compromise to be found either within a department or by locating a president to a position in a research centre.

Appointing committees may select high-profile academics as presidents for external reasons. The alumni may be encouraged to give more generously. Gaining greater media exposure for the institution may be a motive. For example, Anthony Giddens, a distinguished scholar in the field of sociology, who served as Director of the London School of Economics, also exercised political influence in a way that raised a great deal of media interest. Alternatively, if the governing body of a university wants to push an institution in a different direction, towards raising its research output, it may consider appointing a good researcher to signal a change in the internal culture.

The data show that top universities in the US are able to appoint top researchers. Is it that they are more attractive as places to lead and if so what incentives are offered? If we look at salaries, top US presidents earn more than their British counterparts (US information available from Chronicle of Higher Education and in the UK through the Higher Education Statistics Agency). It may be that having a high P-score is associated with high academic achievement at a personal level and this may increase the bargaining power of an individual.

Two interesting studies, one in the UK (Dolton and Ma 2001) and one in the US (Ehrenberg et al, 2001), try to establish whether there is a relationship between presidential pay and university performance. Both papers find that there is only a weak link between pay and performance. A future project might be to understand whether the past research achievement of presidents have an impact on presidential pay. For example, is there a premium for a Nobel Prize winner? In 1982 Hamermesh and colleagues undertook a study looking at the influence of citations on the pay of faculty in economics. They found that economists who were more highly cited commanded a higher salary than those less cited.

Alternatively, are European universities and US publics less attractive to lead because they are subject to greater government intervention whilst also having weaker executive powers? British universities are often accused as being overly bureaucratic because of demands from central government agencies around many areas of university administration and performance (student numbers, quality assurance, research assessment and so on).

4.3 The correlation is explained through unobservable heterogeneity in that people who are good at research may also be good at other things.

This would mean that research talent is merely a proxy for leadership ability. The positive relationship between presidents' P-scores and university rank may actually be picking up a correlation between other variables. For instance, presidents who are good at research may just be good at everything. This is the alternative to a cause-and-effect relationship.

All correlations are potentially susceptible to this criticism. It seems implausible, however, that candidates' research records do not play a part in their selection for headship of institutions with prominent research missions.

5. Concluding comments

This study, which seems to be the first of its kind, finds a correlation between the citations of presidents and the position of universities in a world league table. Better universities are run by better researchers.

The statistical relationship is strong for the group of 100 universities as a whole, and for the sub-samples of female presidents and US presidents. On average, one extra point on a president's adjusted citation score, where scores run from zero for the least-cited president to a score of more than 30 for Highly Cited and Nobel-prize winning presidents, is associated with ten extra points in the world's top-100 ranking of universities. No statistically significant correlation is found, however, for the sub-sample of universities from the rest of the world.

Simple quantitative research of this kind may offer insights into university leadership - insights that are particularly relevant to universities who want to compete for a position amongst the world's top research institutions. The best universities, who can choose from the widest pool, are systematically selecting better researchers to lead them.

What do such researchers bring to the role of leader? This paper posits that there are two central components involved in leading research universities: managerial expertise and inherent knowledge. It is suggested here that better researchers may have greater inherent knowledge about academe that in turn informs their role as leader.

A president's research background may also have symbolic value in that it sends out a signal – both to the university community and outside – about the values of that institution. And finally, being a reputed researcher may raise a leader's status within the academic community and enhance his or her powers of negotiation.

However, the paper notes that other interpretations of the data are possible. One is that universities choose top researchers for reasons of prestige and to assist in fund-raising. This is probably true as a factor for selection, though it is unlikely to be the sole function of a president in a top institution. Another is that research ability is simply a proxy for some other kind of talent that is useful to leaders.

Causality cannot be established through these correlations. The performance of a university has not been shown here to be linked to a president or vice chancellor, whether highly cited or not. However, this type of study starts the process of understanding whether there may be benefits from appointing a researcher as president. A companion paper, Part 2, turns to causality and a different form of evidence.

Figure 1. The cross-country distribution of the world's top 100 universities

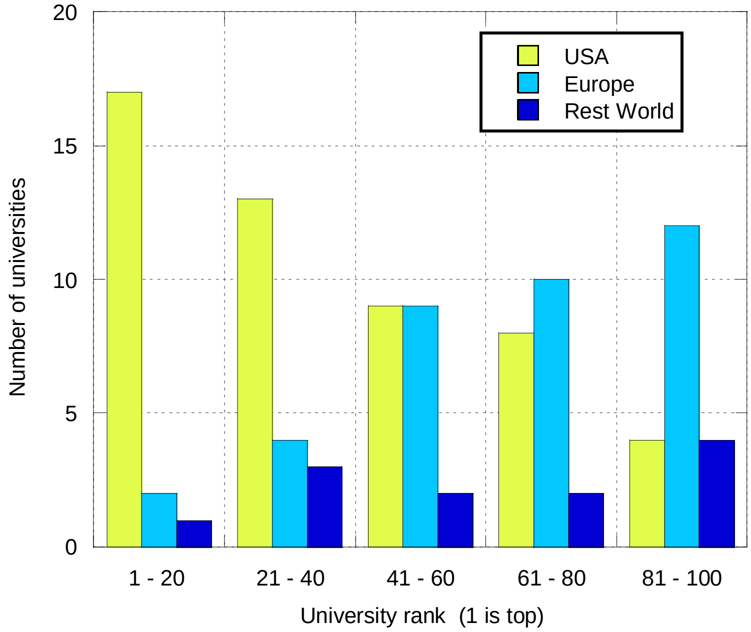


Figure 2. The disciplines of the presidents of the world's top universites

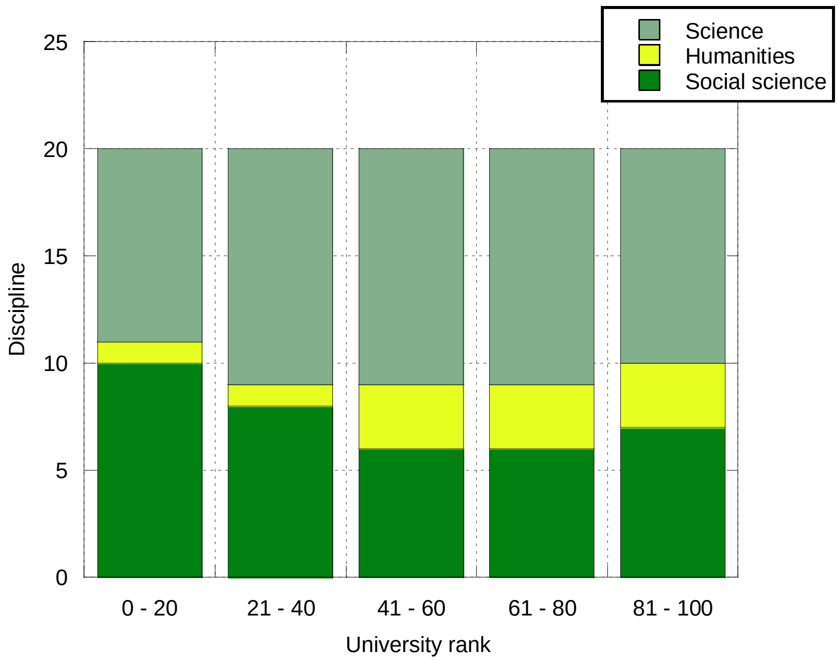


Figure 3. The distribution of presidents' lifetime citations follows Lotka's power law

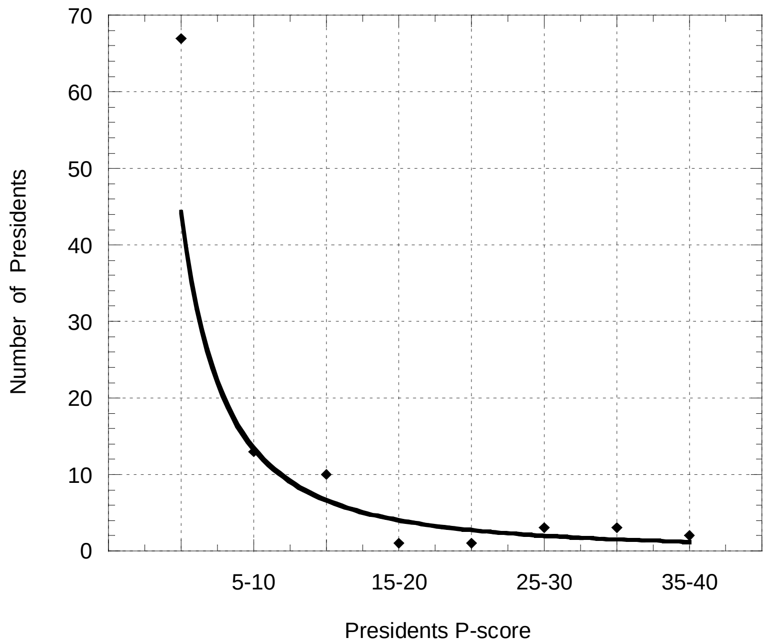


Figure 4. **A cross-tabulation of presidents' lifetime citation P-scores by world university rank (in quintiles)**

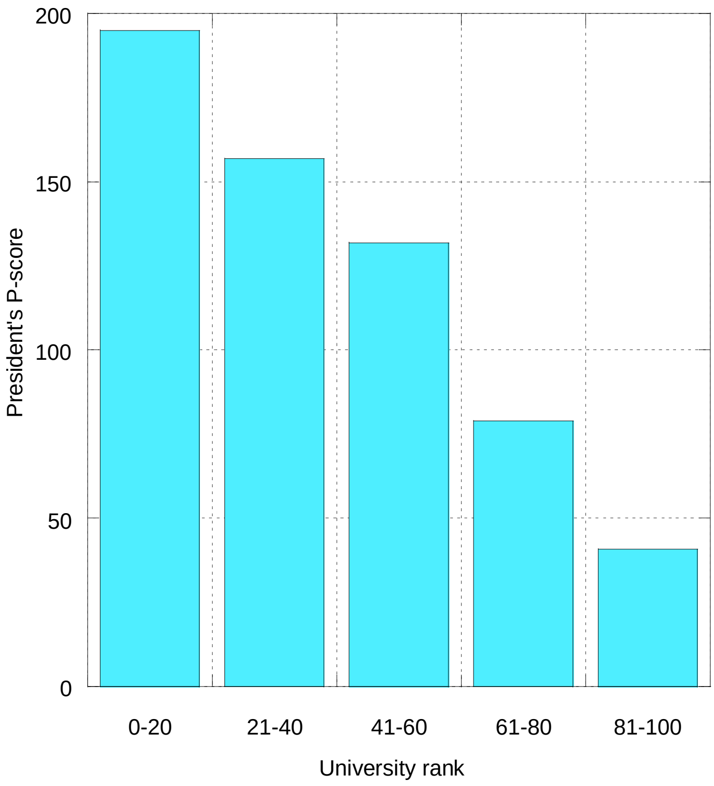


Figure 5. Presidents' P-scores by rank among the world's top-100 universities

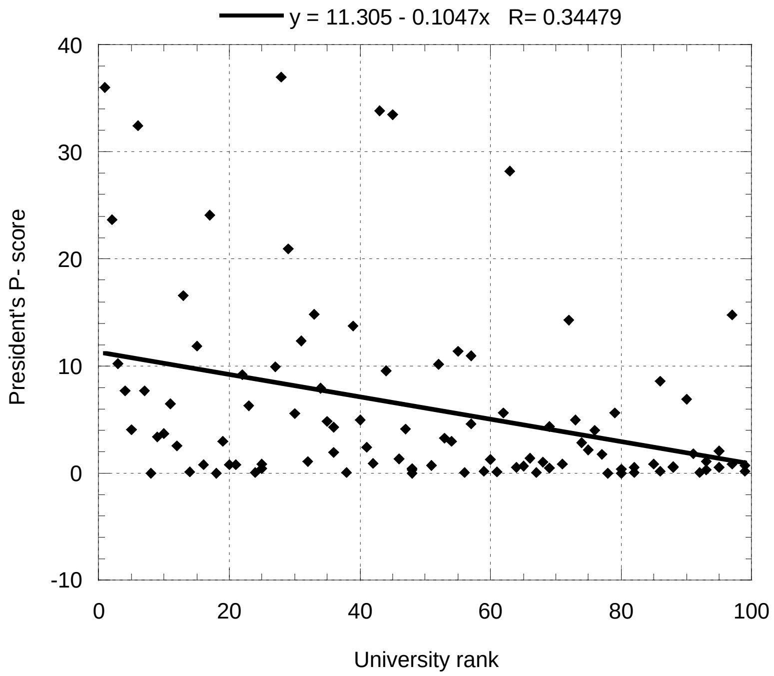


Figure 5a. Logarithm of presidents' P-scores by university rank

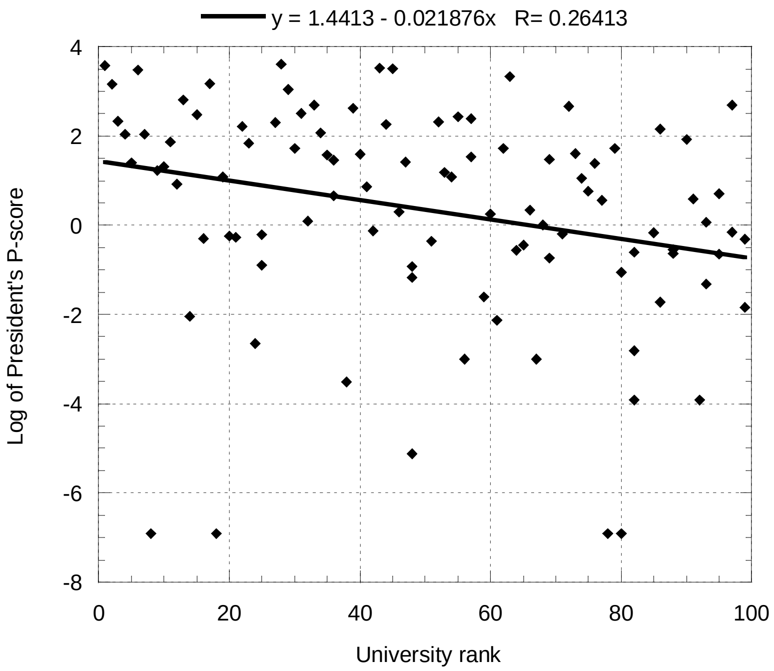


Figure 6. Female presidents' P-scores by university rank

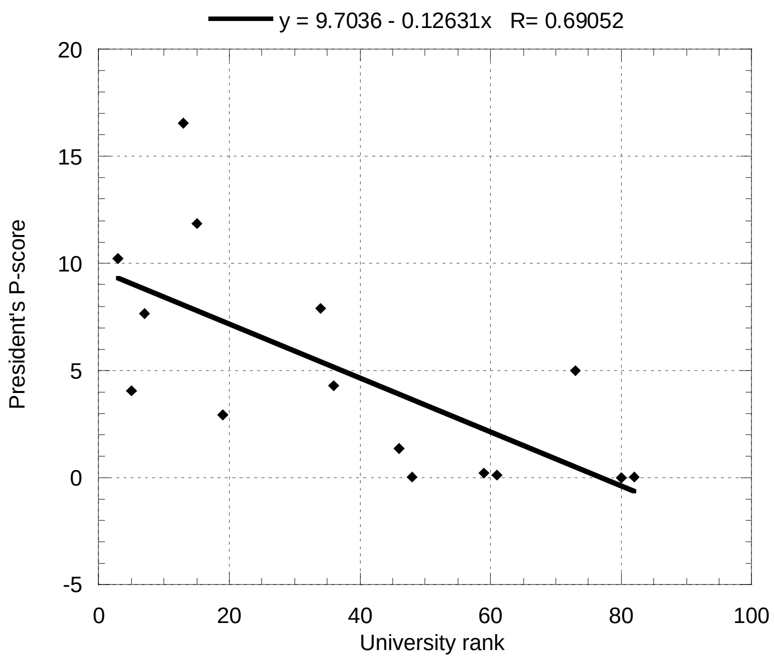


Figure 7. US presidents' P-scores by university rank

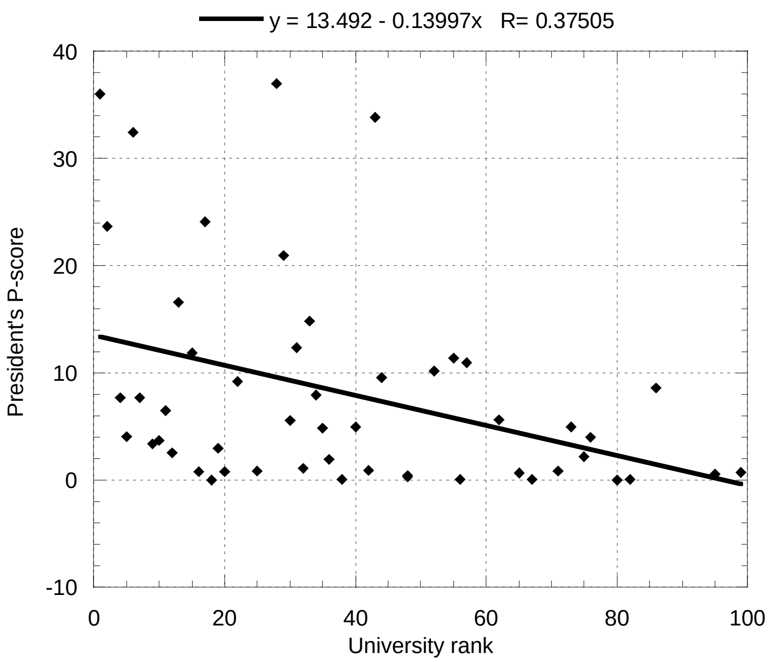


Figure 8. A cross-tabulation of US presidents' P-scores by university rank in top 50 US universities

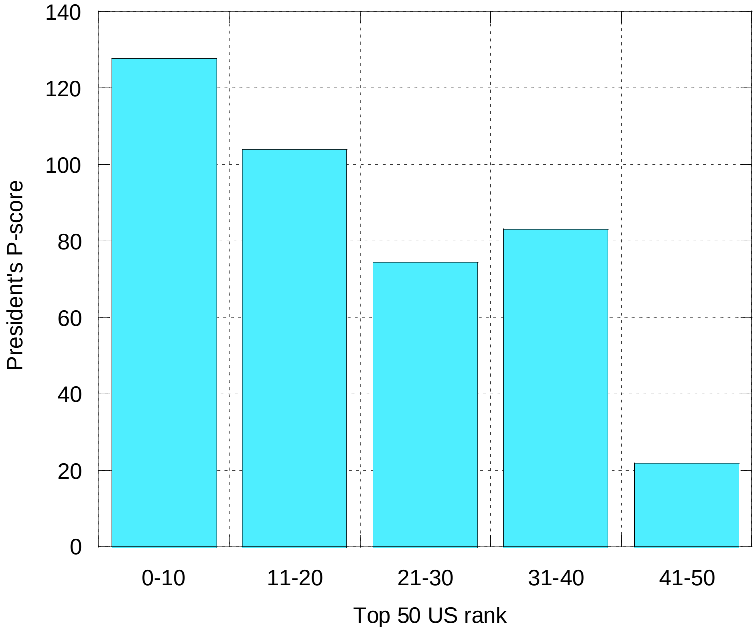


Figure 9. A cross-tabulation of presidents from top 48 in rest of the world (i.e. excluding the US)

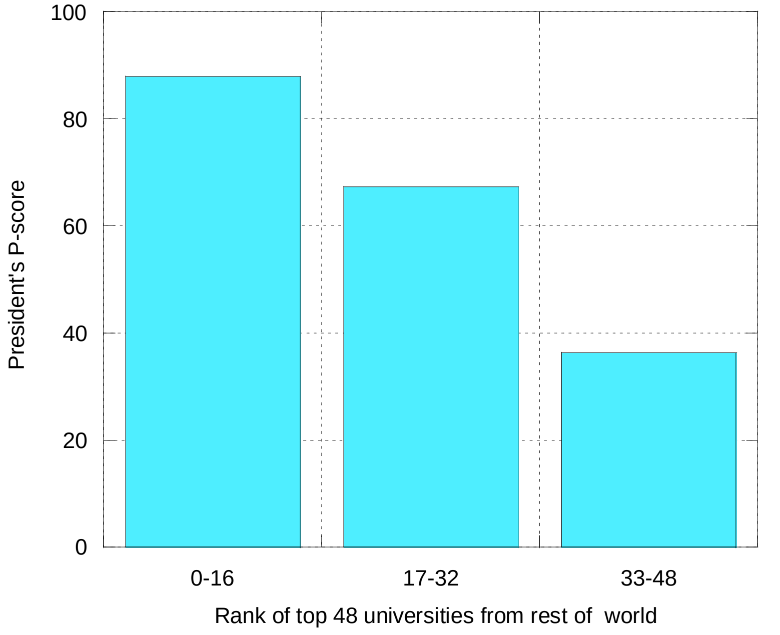


Figure 10. Presidents from the rest of the world P-scores by university rank

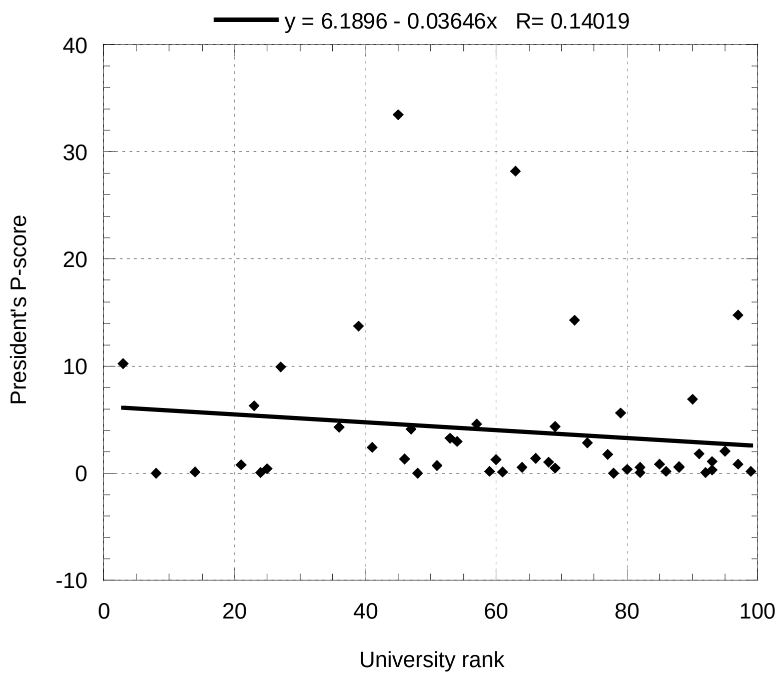


Figure 11. The number of ISI Highly Cited researchers in USA, Europe and rest of the world

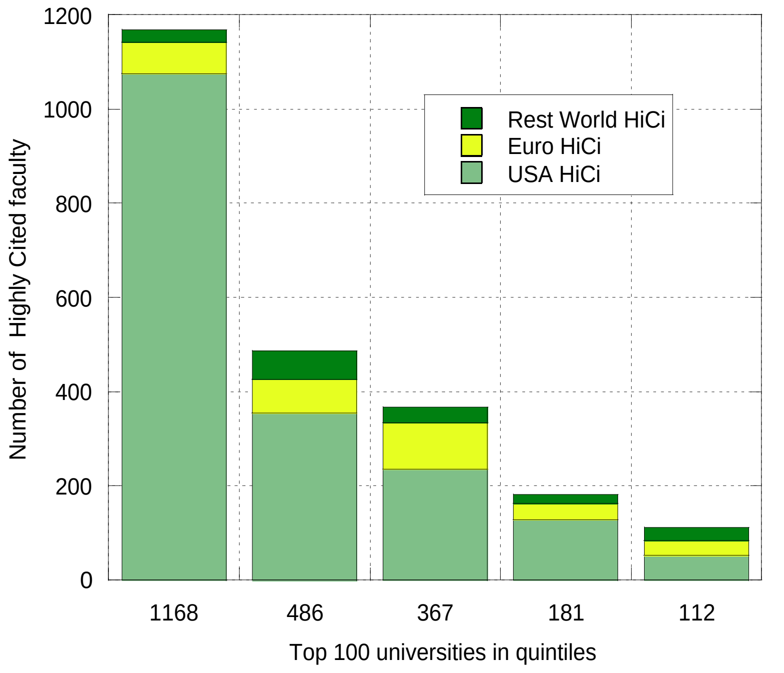


Figure 12. Presidents' P-scores by the number of Highly Cited faculty in each university

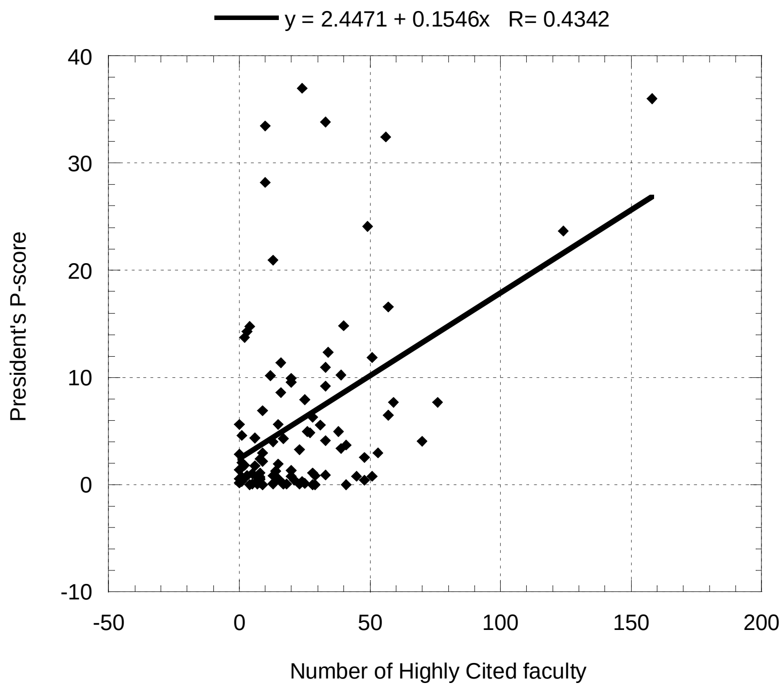
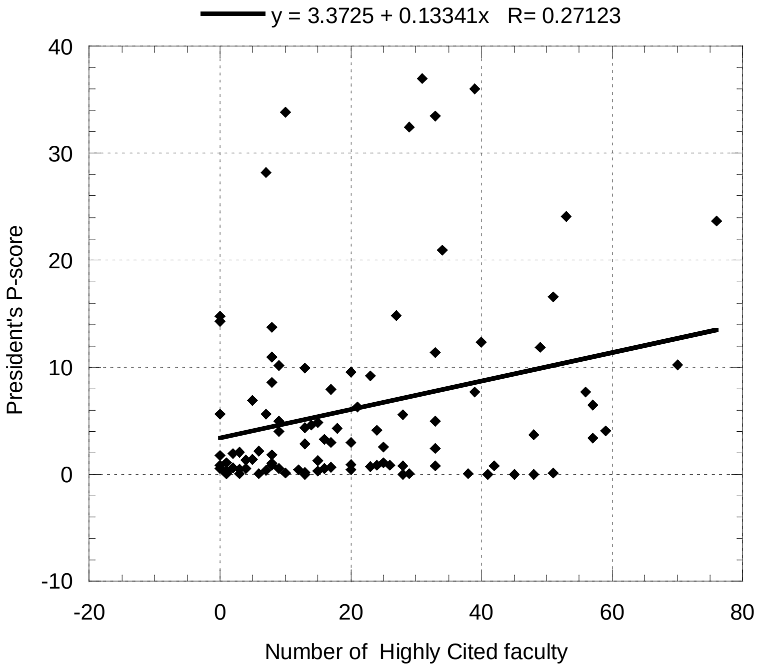


Figure 12a. **Presidents' P-scores by the number of Highly Cited faculty in each university (excluding Harvard and Stanford)**



References

Bargh, C, Bocock, J, Scott, P. and Smith, D. (2000) *University Leadership: The Role of the Chief Executive*. Buckingham, UK: SRHE and Open University Press.

Barnett, R. (2000) *Realizing the University in An Age of Supercomplexity*. Buckingham, UK: Open University Press.

Becher, T. (1993) *Academic Tribes and Territories*. Buckingham, UK: SRHE and Open University Press.

Berquist, W. H. (1992) *The Four Cultures of the Academy: Insights and Strategies for Improving Leadership in Collegiate Organizations.* San Francisco: Jossey-Bass.

Bok, D. (2003) *Universities in the Marketplace: The commercialisation of Higher Education*, New Jersey: Princeton University Press.

Chait, R.P, Ryan, W.P. and Taylor, B.A. (2005) *Governance as Leadership*, New Jersey, USA: John Wiley & Sons.

Cohen, M.D. and March, J.G. (1974), *Leadership and Ambiguity.* New York, USA: McGraw-Hill.

Collison, P, and Millen, J. (1969) University chancellors, vice chancellors and college principals: A social profile', *Sociology*, 3, 1, 77-109.

Cronin, B. Snyder, H. and Atkins H. (1997) Comparative citation rankings of authors in monographic and journal literature: a study of sociology, *Journal of Documentation*, 53, 3, 263-273.

Damrosch, D. (1995) *We Scholars: Changing the Culture of the University*. Cambridge, Mass. USA: Harvard University Press.

Dolton, P. and Ma. A. (2001) CEO Pay in the Public Sector: The Case of Vice Chancellors in UK Universities, Newcastle UK: Working paper, Newcastle University Discussion Papers in Economics.

Ehrenberg, R.G. Cheslock, J.J. and Epifantseva, J. (2001) Paying our Presidents: What Do Trustees Value? Cornell University, USA : Working paper, Cornell Higher Education Research Institute (CHERI).

Fassoulaki, A. Paraskeva, A. Papilas, K. and Karabinis, G. (2000) Self-citations in six anaesthesia journals and their significance in determining the impact factor. *British Journal of Anaesthesia*, 87, 2, 266-269.

Hamermesh, D.S. Johnson, G.E. and Weisbrod, B.A. (1982) Scholarship, Citations and Salaries: Economic Rewards in Economics. *Southern Economic Journal*, 49, 2.

Hamermesh, D.S. (1994) Facts and Myths about Refereeing, *Journal of Economic Perspectives*. 8, 1, Winter, 153-163.

King, D.A. (2004) The scientific impact of nations. *Nature*, 430, 311-316.

Lombardi, J.V. Craig, D.D. Capaldi, E.D. and Gater, D.S. (2002) The Top American Research Universities: An Overview. University of Florida, Gainesville, USA: *TheCenter* Reports.

Lombardi, J.V. Craig, D.D. Capaldi, E.D. Reeves, K.R. and Gater, D.S. (2003) *The Top American Research Universities.* University of Florida, Gainesville, USA: *TheCenter.*

Lotka, A.J. (1926) The Frequency Distribution of Scientific Productivity. *Journal of the Washington Academy of Sciences*, 16,12, 317-323.

Martin, J. and Samels, J.E. (1997) *First Among Equals*. Baltimore, Maryland, USA: Johns Hopkins University Press.

Middlehurst, R. (1993) *Leading Academics*. Buckingham, UK; SRHE and Open University Press.

Moed, H.F. (2002) The impact factors debate: the ISI's uses and limits. *Nature*, 415, 731-732.

Norris, M. and Oppenheim, C. (2003) Citation counts and the Research Assessment Exercise V – Archaeology and the 2001 RAE. *Journal of Documentation*, 59, 6, 709-730.

Oppenheim, C. (1997) The correlation between citation counts and the 1992 Research Assessment Exercise ratings for British research in genetics, anatomy and archaeology. *Journal of Documentation*, 53, 5, 477-487.

Polanyi, M. (1967) *The Tacit Dimension*. New York, USA: Anchor Books.
Potter, W. G. (1988) Of Making Many Books There is No End: Bibliometrics and Libraries. *The Journal of Academic Librarianship* 14, 238a-238c.
Ramsden, P. (2000) *Learning to Lead in Higher Education*. London, UK: Routledge.
Rosenzweig, R.M. (2001) *The Political University*. Baltimore, Maryland, USA: Johns Hopkins University Press.
Rosovsky, H. (1991) *The University: An Owners Manual*. New York, USA: Norton.
Sharp, S. (2004) The Research Assessment Exercises 1992-2001: patterns across time and subjects. *Studies in Higher Education*, 29, 2, 201-218.
Shattock, Michael (2003) *Managing Successful Universities* Open University Press England
Smith, A. and Eysenck, M. (2002) The correlation between RAE ratings and citation counts in psychology. University of London, UK: Working paper, Department of Psychology, Royal Holloway.
Taylor, W, (1986) Organisational Culture and Administrative Leadership in Universities. In *Leadership and Organisational Culture* (eds. Sergiovanni, T.J. and Corbally, J.E.) pp.125-141. University of Illinois, USA: Illini Books.
van Leeuwen, T.N. Moed, H.F. Tijssen, R.J.W. Visser, M.S. and Van Raan, A.F.J. (2001) Language biases in the coverage of the Science Citation Index and its consequences for international comparisons of national research performance'. *Scientometrics*, 51, 1, 335-346.
van Raan, A.F.J. (1998) Assessing the social sciences: the use of advanced bibliometric methods as a necessary complement to peer review. *Research Evaluation*, 7, 2-6.
van Raan, A.F.J. (2003) The use of bibliometric analysis in research performance assessment and monitoring of interdisciplinary scientific developments. *Technikfolgenabschatzung*, 1, 20-29.
van Raan, A.F.J. (2005) Fatal Attraction: Conceptual and methodological problems in the ranking of universities by bibliometric methods. *Scientometrics*, 62, 1, 133-143.
Weingart, P. (2003) Evaluation of research performance: the danger of numbers. In *Bibliometric analysis in science and research: Applications, Benefits and Limitations*. Second Conference of the Central Library, Forschungszentrum Julich, pp. 7-19.
Weingart, P. (2004) Impact of bibliometrics upon the science system: inadvertent consequences? in *Handbook on Quantitative Science and Technology Research*, (eds. Moed, H.F. Glanzel, W. and Schmoch, U.). Dordrecht, The Netherlands: Kluwer Academic Publishers.
Wouters, P.F. (1999) *The Citation Culture*. PhD Thesis. The Netherlands. University of Amsterdam.

League tables

Academic Ranking of World Universities – 2004, Institute of Higher Education, Shanghai Jiao Tong University [http://ed.sjtu.edu.cn/ranking.htm]

Top American Research Universities, *TheCenter* [http://thecenter.ufl.edu]

Statistical packages

'Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4(1): 9pp. [http://palaeo-electronica.org/2001_1/past/issue1_01.htm]

'KaleidaGraph', Synergy Software at [www.synergy.com].

APPENDIX 1.

Top 500 World Universities (1-100)

World Rank	Institution	Country	Total Score	Score on Alumni	Score on Award	Score on HiCi	Score on N&S	Score on SCI	Score on Size
1	Harvard Univ	USA	100.0	98.6	100.0	100.0	100.0	100.0	60.6
2	Stanford Univ	USA	77.2	41.2	72.2	96.1	75.2	72.3	68.1
3	Univ Cambridge	UK	76.2	100.0	93.4	56.6	58.5	70.2	73.2
4	Univ California - Berkeley	USA	74.2	70.0	76.0	74.1	75.6	72.7	45.1
5	Massachusetts Inst Tech (MIT)	USA	72.4	74.1	78.9	73.6	69.1	64.6	47.5
6	California Inst Tech	USA	69.0	59.3	66.5	64.8	66.7	53.2	100.0
7	Princeton Univ	USA	63.6	61.0	76.8	65.4	52.1	46.8	67.3
8	Univ Oxford	UK	61.4	64.4	59.1	53.1	55.3	65.2	59.0
9	Columbia Univ	USA	61.2	77.8	58.8	57.3	51.6	68.3	37.0
10	Univ Chicago	USA	60.5	72.2	81.9	55.3	46.6	54.1	32.7
11	Yale Univ	USA	58.6	52.2	44.5	63.6	58.1	63.6	50.4
12	Cornell Univ	USA	55.5	46.6	52.4	60.5	47.2	66.2	33.6
13	Univ California - San Diego	USA	53.8	17.8	34.7	63.6	59.4	67.2	47.9
14	Tokyo Univ	Japan	51.9	36.1	14.4	44.5	55.0	91.9	49.8
15	Univ Pennsylvania	USA	51.8	35.6	35.1	61.2	44.6	72.6	34.0
16	Univ California - Los Angeles	USA	51.6	27.4	32.8	60.5	48.1	79.9	24.8
17	Univ California - San Francisco	USA	50.8	0.0	37.6	59.3	59.5	62.9	48.8
18	Univ Wisconsin - Madison	USA	50.0	43.1	36.3	55.3	48.0	69.2	19.0
19	Univ Michigan - Ann Arbor	USA	49.3	39.8	19.3	64.8	45.7	76.7	20.1
20	Univ Washington - Seattle	USA	49.1	22.7	30.2	57.3	49.6	78.8	16.2
21	Kyoto Univ	Japan	48.3	39.8	34.1	40.0	37.2	77.1	46.4
22	Johns Hopkins Univ	USA	47.5	48.7	28.3	43.7	52.6	71.7	14.2
23	Imperial Coll London	UK	46.4	20.9	38.1	46.2	39.4	65.8	44.5
24	Univ Toronto	Canada	44.6	28.1	19.7	39.1	41.2	78.4	42.8
25	Univ Coll London	UK	44.3	30.8	32.9	41.0	41.0	61.1	42.6
25	Univ Illinois - Urbana Champaign	USA	43.3	41.7	37.4	46.2	36.0	58.2	17.8
27	Swiss Fed Inst Tech - Zurich	Switzerland	43.2	40.3	37.0	39.1	43.2	47.1	41.5

28	Washington Univ - St. Louis	USA	43.1	25.1	26.6	41.9	46.8	56.2	44.9
29	Rockefeller Univ	USA	40.2	22.7	59.8	31.5	43.6	27.1	38.6
30	Northwestern Univ	USA	39.5	21.8	19.3	47.9	35.8	57.2	37.0
31	Duke Univ	USA	38.9	20.9	0.0	48.6	46.8	62.7	36.2
32	New York Univ	USA	38.7	33.9	25.0	43.7	39.3	50.9	19.1
33	Univ Minnesota - Twin Cities	USA	38.3	36.1	0.0	53.9	35.9	69.6	12.8
34	Univ Colorado - Boulder	USA	37.8	16.6	29.8	43.7	38.3	47.5	27.4
35	Univ California - Santa Barbara	USA	37.0	0.0	28.5	45.4	41.4	44.0	36.2
36	Univ British Columbia	Canada	36.3	20.9	19.3	36.0	31.6	59.5	34.9
36	Univ Texas Southwestern Med Center	USA	36.3	16.6	33.9	33.8	40.5	40.0	34.9
38	Vanderbilt Univ	USA	35.1	12.6	30.2	37.1	23.8	50.2	41.7
39	Univ Utrecht	Netherlands	34.9	30.8	21.4	31.5	29.9	58.1	22.1
40	Univ Texas - Austin	USA	34.8	21.8	17.1	50.2	28.8	53.7	12.8
41	Univ Paris 06	France	33.9	35.7	23.9	23.1	24.7	56.7	32.6
42	Univ California - Davis	USA	33.6	0.0	0.0	48.6	37.2	64.7	20.7
43	Pennsylvania State Univ - Univ Park	USA	33.5	14.1	0.0	50.2	37.7	58.7	14.2
44	Rutgers State Univ - New Brunswick	USA	33.4	15.4	20.4	38.1	36.1	48.2	19.5
45	Tech Univ Munich	Germany	33.3	43.1	24.1	27.6	20.4	50.0	32.0
46	Karolinska Inst Stockholm	Sweden	33.0	30.8	27.8	32.7	21.6	49.8	21.5
47	Univ Edinburgh	UK	32.9	22.7	17.1	27.6	36.7	49.1	31.6
48	Univ Paris 11	France	32.5	33.3	34.2	21.4	21.3	46.8	31.2
48	Univ Pittsburgh - Pittsburgh	USA	32.5	18.9	0.0	42.8	26.5	67.0	20.0
48	Univ Southern California	USA	32.5	0.0	27.3	41.9	23.0	53.5	20.5
51	Univ Munich	Germany	32.4	37.2	21.1	12.4	32.0	56.0	31.1
52	Univ Rochester	USA	32.0	33.3	9.1	30.3	27.2	44.9	50.1
53	Australian Natl Univ	Australia	31.9	17.8	12.9	41.0	31.4	43.6	30.7
54	Osaka Univ	Japan	31.5	12.6	0.0	26.2	31.2	72.1	30.2
55	Univ California - Irvine	USA	31.4	0.0	25.0	33.8	29.6	47.2	29.9
56	Univ North Carolina - Chapel Hill	USA	31.2	12.6	0.0	38.1	34.5	60.5	20.3
57	Univ Maryland - Coll Park	USA	31.1	25.9	0.0	40.0	33.2	54.0	17.4
57	Univ Zurich	Switzerland	31.1	12.6	27.3	21.4	30.3	48.9	29.9

59	Univ Copenhagen	Denmark	31.0	30.8	24.7	23.1	22.6	48.1	29.8
60	Univ Bristol	UK	30.6	10.9	18.2	32.7	26.6	49.1	29.4
61	McGill Univ	Canada	30.4	28.8	0.0	31.5	26.3	59.0	29.2
62	Carnegie Mellon Univ	USA	30.3	18.9	30.2	32.7	17.4	38.8	34.0
63	Univ Leiden	Netherlands	29.8	25.1	15.8	30.3	22.0	47.3	30.3
64	Univ Heidelberg	Germany	29.7	10.9	27.7	23.1	22.1	49.7	28.5
65	Case Western Reserve Univ	USA	29.6	37.2	11.8	23.1	22.2	46.1	40.6
66	Moscow State Univ	Russia	29.5	51.5	34.9	0.0	8.1	58.5	28.3
67	Univ Florida	USA	29.3	15.4	0.0	33.8	24.3	66.4	16.3
68	Univ Oslo	Norway	29.2	25.9	34.1	19.5	17.2	42.1	28.0
69	Tohoku Univ	Japan	28.8	18.9	0.0	19.5	26.1	69.3	27.7
69	Univ Sheffield	UK	28.8	23.5	14.4	23.1	28.8	46.2	27.7
71	Purdue Univ - West Lafayette	USA	28.7	18.9	17.1	31.5	22.1	50.5	13.8
72	Univ Helsinki	Finland	28.6	18.9	18.2	15.1	23.7	56.9	27.5
73	Ohio State Univ - Columbus	USA	28.5	17.8	0.0	41.0	20.6	61.3	9.6
74	Uppsala Univ	Sweden	28.4	25.9	32.9	0.0	30.4	52.5	14.5
75	Rice Univ	USA	28.3	21.8	22.3	26.2	23.7	30.2	44.6
76	Univ Arizona	USA	28.1	0.0	0.0	31.5	37.7	56.5	18.1
77	King's Coll London	UK	28.0	16.6	23.5	23.1	19.8	46.2	26.9
78	Univ Manchester	UK	27.9	25.9	19.3	21.4	18.2	48.6	26.8
79	Univ Goettingen	Germany	27.4	38.8	20.4	17.5	18.2	42.8	26.3
80	Michigan State Univ	USA	27.0	12.6	0.0	39.1	28.4	50.5	10.5
80	Univ Nottingham	UK	27.0	15.4	20.4	23.1	20.1	45.1	25.9
82	Brown Univ	USA	26.8	0.0	13.9	30.3	27.9	41.4	30.4
82	Univ Melbourne	Australia	26.8	15.4	14.4	21.4	19.2	53.0	25.8
82	Univ Strasbourg 1	France	26.8	29.5	22.9	21.4	21.3	35.2	25.7
85	Ecole Normale Super Paris	France	26.5	47.9	25.0	17.5	18.2	29.6	25.4
86	Boston Univ	USA	26.3	15.4	0.0	32.7	29.6	51.5	9.6
86	Univ Vienna	Austria	26.3	25.1	15.8	8.7	22.0	54.5	25.3
88	McMaster Univ	Canada	26.0	16.6	19.3	23.1	16.2	45.2	25.0
88	Univ Freiburg	Germany	26.0	25.1	21.4	19.5	18.0	40.9	25.0

90	Hebrew Univ Jerusalem	Israel	25.9	15.4	0.0	26.2	29.5	48.3	24.9
91	Univ Basel	Switzerland	25.8	25.9	17.5	21.4	24.2	35.5	24.8
92	Lund Univ	Sweden	25.6	29.5	0.0	26.2	22.0	54.0	11.2
93	Univ Birmingham	UK	25.5	25.1	11.2	24.7	14.0	47.6	24.5
93	Univ Roma - La Sapienza	Italy	25.5	16.6	15.8	12.4	24.3	57.4	7.9
95	Humboldt Univ Berlin	Germany	25.4	29.5	21.9	8.7	14.8	49.7	24.4
95	Univ Utah	USA	25.4	0.0	0.0	32.7	30.7	48.4	20.1
97	Nagoya Univ	Japan	25.2	0.0	14.4	15.1	23.7	55.3	24.2
97	Stockholm Univ	Sweden	25.2	29.5	30.2	17.5	14.9	35.7	15.3
99	Tufts Univ	USA	25.1	18.9	17.1	19.5	19.1	40.6	29.2
99	Univ Bonn	Germany	25.1	19.9	20.4	17.5	16.7	43.9	24.1

APPENDIX 2.

ISI Highly Cited Papers Thresholds
(January 1994 - June 2004)

Subject area	Scientist*
Agricultural Sciences	154
Biology & Biochemistry	780
Chemistry	648
Clinical Medicine	1095
Computer Science	84
Economics & Business	169
Engineering	182
Environment/Ecology	248
Geosciences	433
Humanities, general*	35
Immunology	763
Materials Science	219
Mathematics	130
Microbiology	534
Molecular Biology & Genetics	1234
Multidisciplinary	123
Neuroscience & Behaviour	908
Pharmacology & Toxicology	312
Physics	1832
Plant & Animal Science	292
Psychiatry/Psychology	393
Social Sciences, general	117
Space Science	1301

Updated Sept 1 2004, Thomson ISI Highly cited

* Humanities score created by Amanda H. Goodall (see below)

Obtaining normalised P-scores

To obtain a P-score the individual presidential citations were divided by the above subject thresholds. The threshold dates correspond to the dates the data were collected within a month. The subject thresholds are being used here as an exchange rate for assessing different citation conventions.

The humanities score was created by using the 'new cited references' generated by ISI each week. Corresponding with the data collection dates as closely as possible, the sciences approximate at 350,000 new cited references weekly, the social sciences 50,000 and the humanities 15,000. If we divide the social science weekly score of 50,000 by the humanities 15,000 we get a figure of 3.33. I have then divided the 'Social Sciences, General' score of 117 (see above) by 3.33 which creates a score of 35.13. I have used 35 as the 'Humanities, general' score.