

# Bibliometrie als Instrument der Forschungsevaluation und Wissenschaftskartografie

DPG-Tagung, Technische Universität Berlin  
26. Februar 2008

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Universiteit Leiden  
The Netherlands



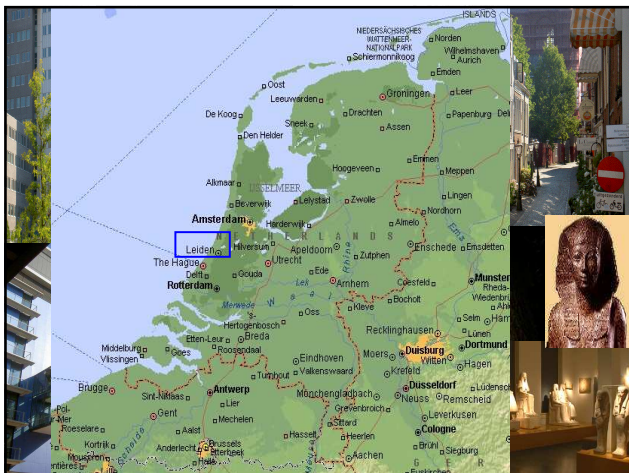
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Leiden University,  
oldest in the Netherlands, 1575,  
European League of Top Research  
Universities (LERU)

Leiden, prominent and historic city (2th,  
11th), strong cultural & scientific tradition  
one of the largest science parks in EU



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This lecture presents the state-of-the-art of an  
advanced bibliometric methodology, fine-tuned to  
the specific demands of the evaluation of  
academic research

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## Construction of Indicators

*Acceptable, Valid, Robust, Reliable, Transparent Measures of Research Impact*

*Comprehensiveness Across the Science-Based Disciplines*

*Identifying High Quality Research*

*Distribution of impact within a department or institute: 'quality profile'*

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## Daily Practice

*Data Collection*

*Definition of staff involved*

*Definition and aggregation of fields*

*Interdisciplinarity*

*Assignment of Researchers to Fields*

*Data Analysis, Normalisation, Aggregation Levels*

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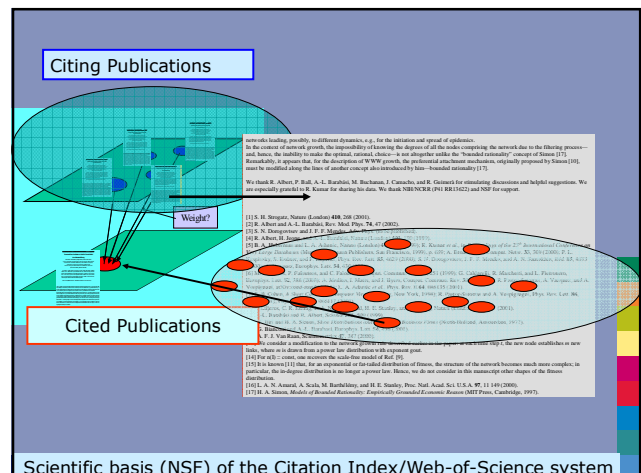
## Basic Concept: How do we focus on 'quality'?

Scientific performance relates to achieved quality in the contribution to the increase of our knowledge ('scientific progress')

- (1) as perceived by others: peer review
- (2) as measured by advanced bibliometric analysis

(1) and (2) correlate (very) well at group level

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## What do citations measure?

- Many studies showed positive correlations between citations and qualitative judgments
- In principle it is valid to interpret citations in terms of intellectual influence which is an important aspect of scientific quality
- Thus, the concepts of citation impact and scientific quality do not coincide 'automatically'

**Quality judgment by peers** may relate to 'tacit knowledge' such as the capability to build instruments, or to acknowledgment of 'being ahead of time' and to 'trust' that a group will come soon with breakthroughs...so peer judgments may include 'credits'....

**Bibliometrics** always relates to 'codified knowledge', high-value 'tacit' knowledge is immeasurable; it never works with credits; but it may concern hypes, fashions, detested by (some) peers.....

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What do scientists think about important aspects of quality?

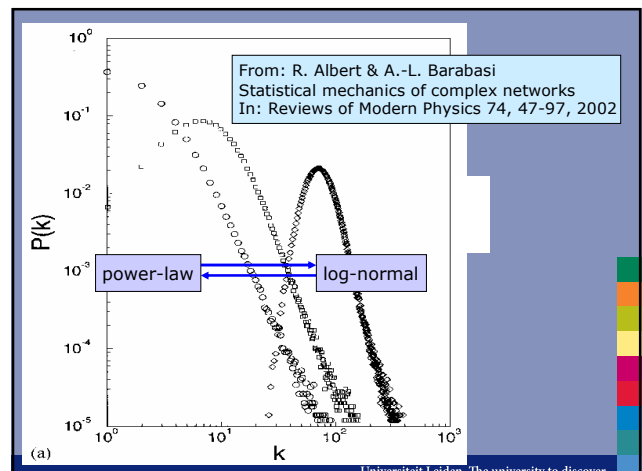
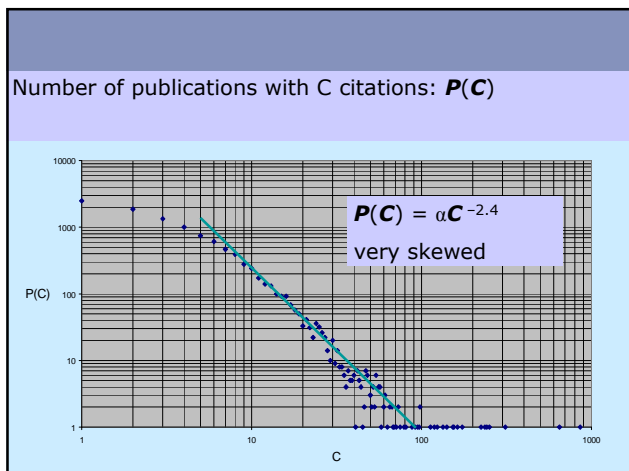
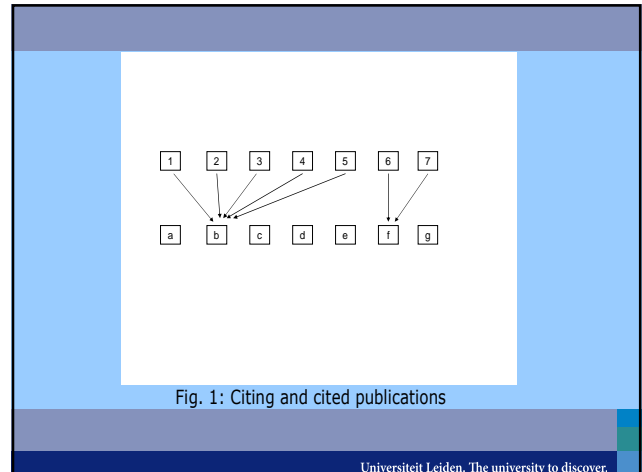
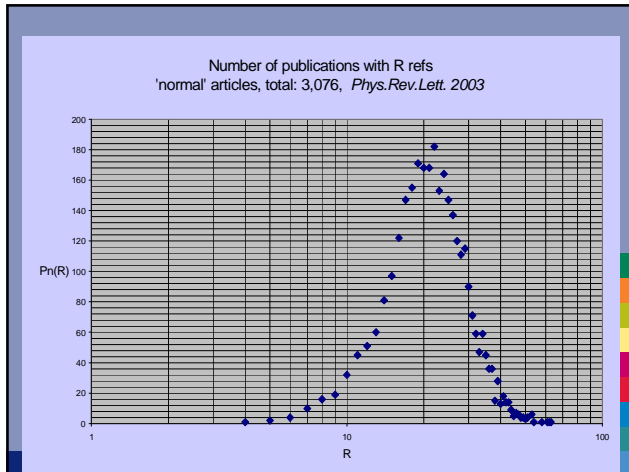
Opinions of prominent physicists in the Netherlands in discussions (1996) about the allocation of extra money to top-groups. As a peer, they focus at:

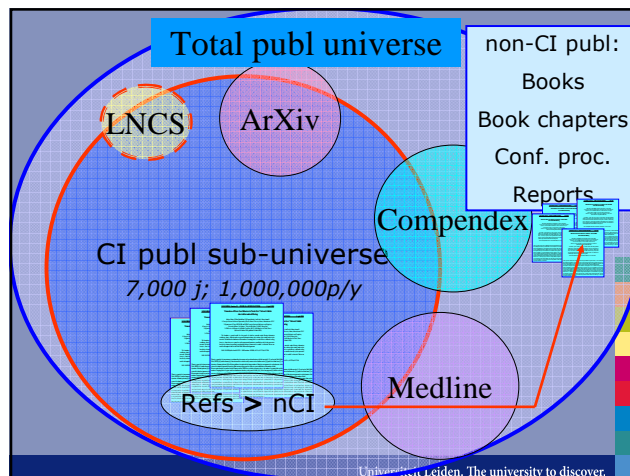
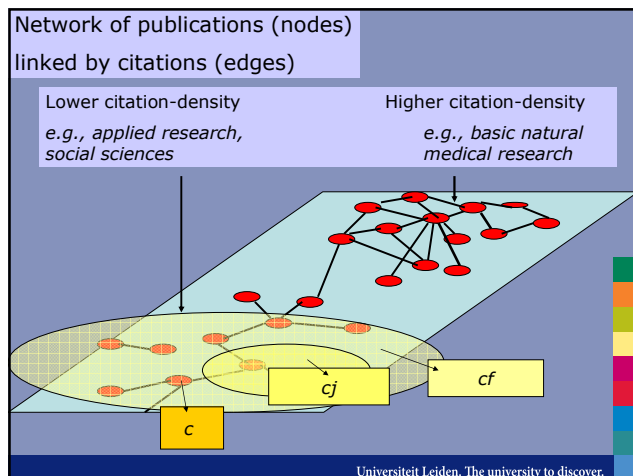
First of all, quality MUST be **demonstrable**, no fine words. Quality of research, at least in physics, is demonstrable in the following aspects:

- \* Effective publication, i.e., in the **best possible journals**;
- \* **Invited lectures** in top-conferences of the field and/or in top-universities;
- \* **High citation** scores
- \* **Citations** in important **reviews**;
- \* **Collaboration** with top-groups;
- \* Continuation of **PhD students**;
- \* Continuation in **research council grants**
- \* **Long-term financing** by the government and/or the business sector

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**Table 3.1:** Internal coverage percentages of the Thomson Scientific/ISI Citation Indexes

Internal Coverage Percentage			
80-100%	60-80%	40-60%	<40%
Biochem & Mol Biol	Appl Phys & Chem	Mathematics	Other Soc Sci
Biol Sci - Humans	Biol Sci - Anim & Plants	Economics	Humanities & Arts
Chemistry	Psychol & Psychiat	Engineering	
Clinical Medicine	Geosciences		
Phys & Astron	Soc Sci ~ Medicine		

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**Table 1:** Internal coverage of the citation index by main field for the University of Heidelberg

Main Field	P 00-04	Avg Nr Refs	Refs <1980	%Refs <1980	Refs Non-CI	Refs CI	%Refs CI
CLINICAL MEDICINE	4,477	33.2	8,240	6%	14,066	126,277	90%
BIOL SCI: HUMANS	2,360	40.4	4,186	4%	6,356	84,756	93%
BIOL SCI: ANIMALS & PLANTS	273	43.5	1,393	12%	2,166	8,305	79%
MOLECULAR BIOLOGY & BIOCHEMISTRY	1,258	45.7	2,584	4%	3,313	51,533	94%
PHYSICS AND ASTRONOMY	1,389	38.4	5,721	11%	8,805	38,820	82%
CHEMISTRY	816	37.4	4,028	13%	5,081	21,374	81%
MATHEMATICS	315	20.4	1,444	22%	2,253	2,736	55%
GEOSCIENCES	404	46.2	2,348	13%	4,875	11,459	70%
APPLIED PHYSICS AND CHEMISTRY	483	26.6	1,117	9%	2,910	8,817	75%
ENGINEERING	373	23.2	823	10%	3,376	4,439	57%
MULTIDISCIPLINARY	120	34.3	294	7%	312	3,508	92%
ECONOMICS	57	30.5	204	12%	695	842	55%
PSYCHOLOGY, PSYCHIATRY & BEHAVIORAL SCIENCES	228	39.8	939	10%	2,140	5,985	74%
SOCIAL SCIENCES RELATED TO MEDICINE	283	35.9	774	8%	3,125	6,273	67%
OTHER SOCIAL SCIENCES	69	32.7	324	14%	1,297	633	33%
HUMANITIES & ARTS	39	42.6	535	32%	937	190	17%

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**Table 2:** Language of publications in Citation Index for the University of Heidelberg

Main Field	All papers 00-04	English Language papers	Other Language papers	% Other Language Papers
CLINICAL MEDICINE	5,577	4,477	1,100	20%
BIOL SCI: HUMANS	2,381	2,360	21	1%
BIOL SCI: ANIMALS & PLANTS	282	273	9	3%
MOLECULAR BIOLOGY & BIOCHEM	1,258	1,258	0	0%
PHYSICS AND ASTRONOMY	1,389	1,389	0	0%
CHEMISTRY	841	816	25	3%
MATHEMATICS	315	315	0	0%
GEOSCIENCES	410	404	6	1%
APPLIED PHYSICS AND CHEMISTRY	504	483	21	4%
ENGINEERING	378	373	5	1%
MULTIDISCIPLINARY	120	120	0	0%
ECONOMICS	60	57	3	5%
PSYCHOLOGY, PSYCHIATRY & BEHAV SC	425	228	197	46%
SOCIAL SCIENCES RELATED TO MEDICINE	335	283	52	16%
OTHER SOCIAL SCIENCES	116	69	47	41%
HUMANITIES & ARTS	107	39	68	64%

## Other citation indexes:

Google Scholar (all types of documents, 'wild west')

ArXiv (physics)

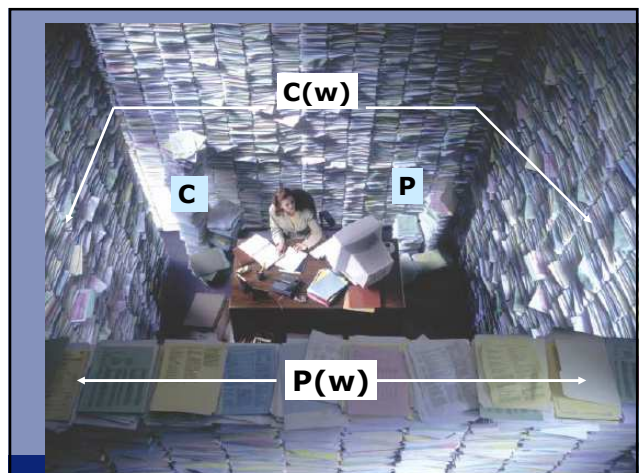
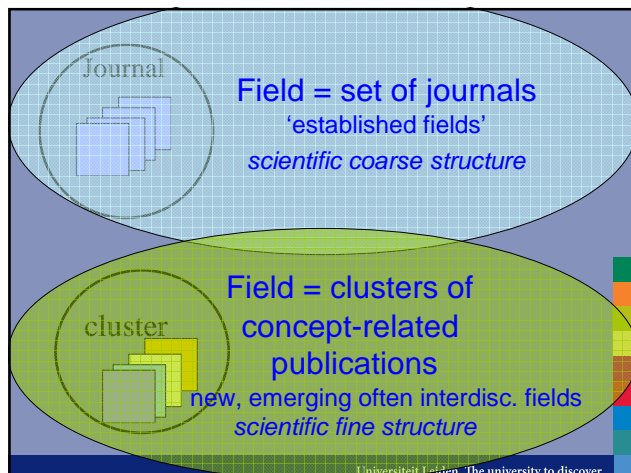
SPIRES (high energy particle physics)

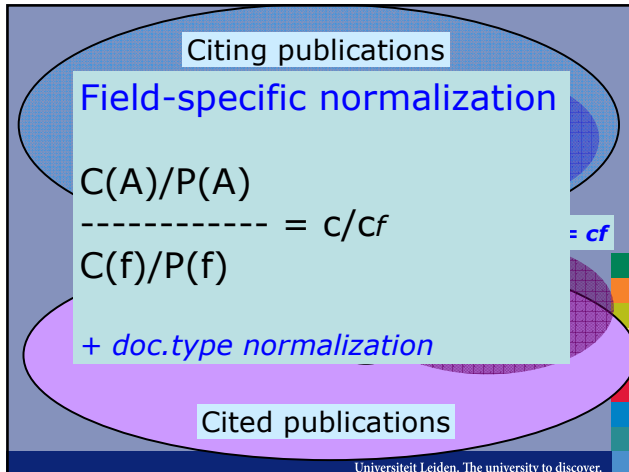
NEC (computer science)

.....

*OK for individual scientists, but undoable for large scale studies, Thomson Scientific/ISI remains superior with WoS as 'gold standard' but...*

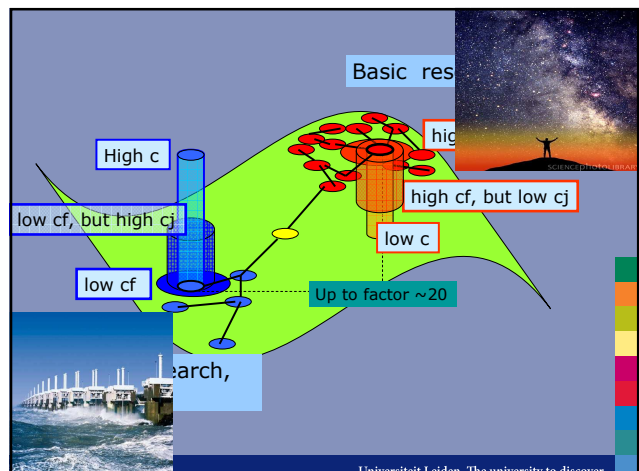
*.....SCOPUS is rapidly becoming the only serious competitor of WoS*





Basic Performance Indicators	
• <b>P</b>	<b>Output:</b> Number of publications in internationally refereed CI-covered journals
• <b>C</b>	<b>Absolute Impact:</b> Number of (self-ex) citations to these publications
• <b>H</b>	Hirsch-index
• <b>c</b>	<b>Output-normalized Impact:</b> Average number of cits/pub of the institute ( <i>CPP</i> )
• <b>cj</b>	Average number of <b>cits/pub of the journal set</b> used by the institute ( <i>JCSm</i> )
• <b>cf</b>	Average number of <b>cits/pub of all journals of a specific field</b> in which the institute is active ( <i>FCSm</i> )
• <b>p0</b>	Percentage of <b>not-cited</b> publications

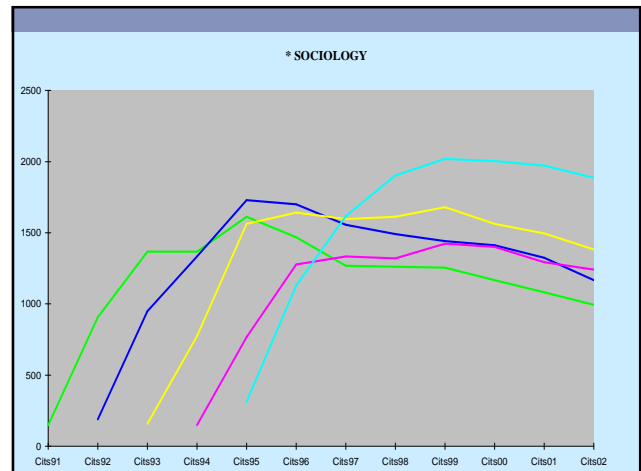
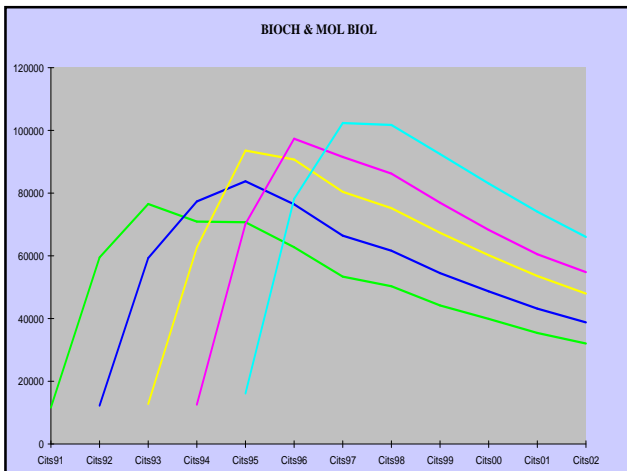
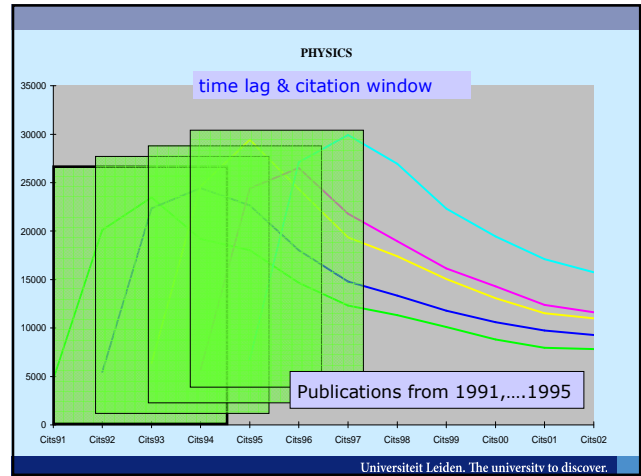
CWTS Key Research Performance Indicators:	
• <b>cj/cf</b>	Relative impact of the <b>used journal set</b> ( <i>JCSm/FCSm</i> )
• <b>c/cj</b>	Internat. <b>journal-normalized</b> impact ( <i>CPP/JCSm</i> )
• <b>c/cf</b>	Internat. <b>field &amp; doc-normalized</b> impact ( <i>CPP/FCSm</i> )
• <b>Pt/Πt</b>	<b>Contribution to the top-5, 10, 20,..%</b>
• <b>P*(c/cf)</b>	<b>Size &amp; Impact Together: Brute Force</b> ( <i>P * CPP/FCSm</i> )



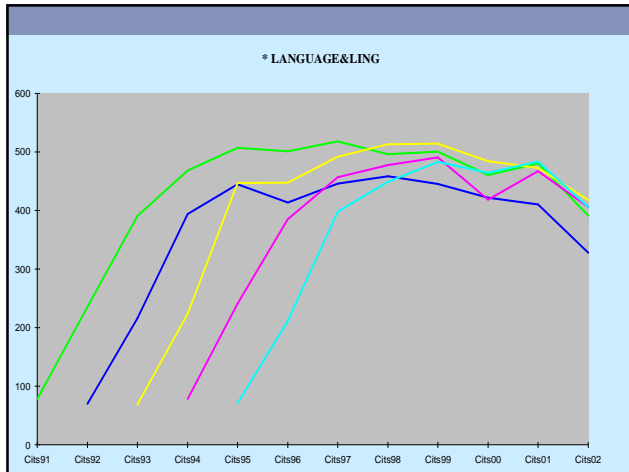


Application of ISI Impact Factors for research performance evaluation is **irresponsible**

- \* Much too short 'Citation window'
- \* No Field-specific Normalization
- \* No distinction between document types
- \* Calculation errors/inconsistencies (nominator/denominator)







Examples from recent studies

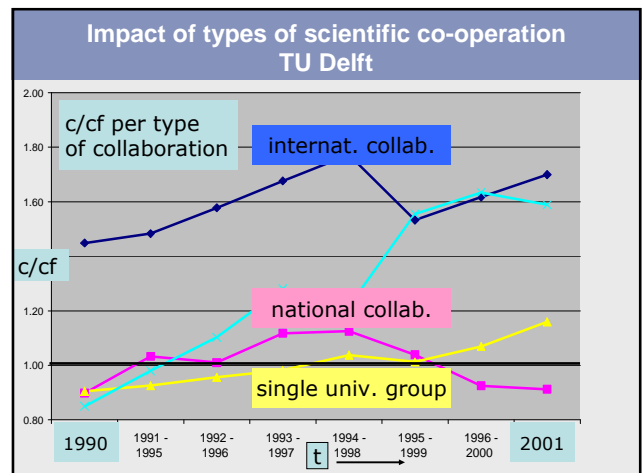
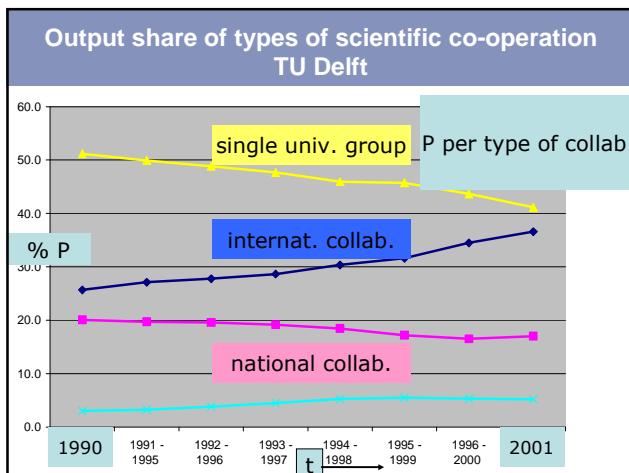
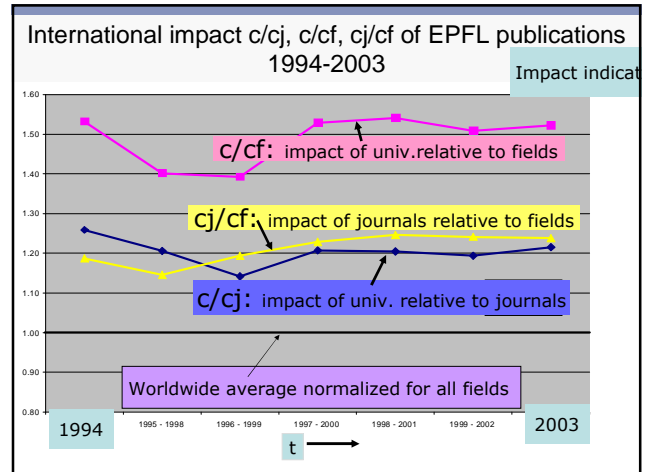
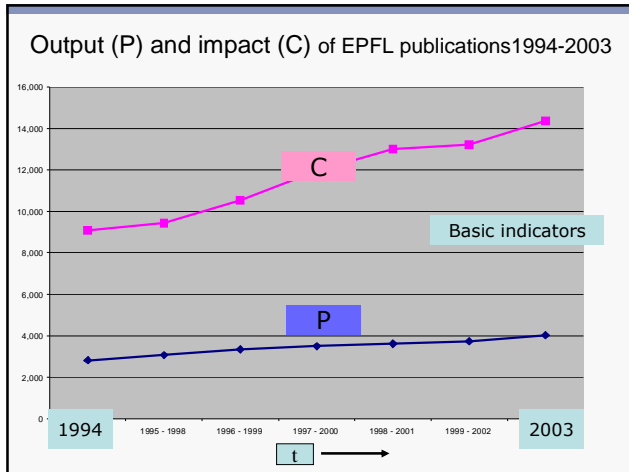
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Leiden Ranking 1: Top 100 European Universities, yellow list							
	University		P	C	GPP	Pnc	CPP/ FCSm
ranking	1 UNIV CAMBRIDGE	UK	36.349	361.681	9.95	29.1	1.63
by	2 UNIV COLL LONDON	UK	34.407	346.028	10.06	26.9	1.46
number of	3 UNIV OXFORD	UK	33.780	355.856	10.53	29.5	1.67
publications	4 IMPERIAL COLL LONDON	UK	27.017	222.713	8.24	30.7	1.45
P	5 KATHOLIEKE UNIV LEUVEN	BE	22.521	153.851	6.83	34.9	1.22
	6 LUDWIG MAXIMILIANS UNIV MUNICHEN	DE	23.519	177.317	7.54	30.8	1.14
	7 UNIV PARIS VI PIERRE & MARIE CURIE	FR	23.458	146.483	6.24	32.8	1.09
	8 UNIV MILANO	IT	23.006	175.181	7.61	30.0	1.11
	9 UNIV UTRECHT	NL	22.668	189.671	8.37	28.3	1.37
	10 UNIV MANCHESTER	UK	22.470	137.812	6.13	34.4	1.16
	11 UNIV WIEN	AT	21.940	137.251	6.26	32.9	1.01
	12 UNIV ROMA SAPIENZA	IT	21.778	119.076	5.47	37.7	0.95
	13 TEL AVIV UNIV	IL	21.447	112.337	5.24	35.9	0.94
	14 UNIV HELSINKI	FI	21.034	179.662	8.54	28.5	1.38
	15 LUNDS UNIV	SE	20.631	157.944	7.66	27.9	1.21
	16 KAROLINSKA INST STOCKHOLM	SE	20.525	213.629	10.41	23.2	1.30
	17 KOBENHAVNS UNIV	DK	19.555	153.583	7.85	27.4	1.18
	18 UNIV AMSTERDAM	NL	19.333	163.417	8.45	28.9	1.35
	19 UPPSALA UNIV	SE	18.998	140.518	7.40	28.6	1.17
	20 RUPRECHT KARLS UNIV HEIDELBERG	DE	18.735	155.451	8.30	30.1	1.22
	21 ETH ZURICH	CH	18.611	148.078	7.96	29.8	1.52
	22 KINGS COLL UNIV LONDON	UK	18.601	161.460	8.68	28.7	1.32
	23 HEBREW UNIV JERUSALEM	IL	18.389	127.263	6.92	33.2	1.16
	24 UNIV PARIS XI SUD	FR	18.183	115.157	6.33	32.8	1.13
	25 UNIV EDINBURGH	UK	17.786	164.380	9.24	29.7	1.48
	26 HUMBOLDT UNIV BERLIN	DE	17.780	127.381	7.16	31.6	1.13
	27 LEIDEN UNIV	NL	16.832	147.821	8.78	26.9	1.26
	28 UNIV ZURICH	CH	16.783	154.154	9.19	29.2	1.33
	29 UNIV BARCELONA	ES	16.783	103.628	6.17	32.4	1.03
	30 UNIV BRISTOL	UK	16.387	119.860	7.32	29.7	1.31

250 European Universities with P(y) > 350  
Top-20 in 'size', Physics, ranked by crown indicator'

DE	UNIV KARLSRUHE (TH)	2174,8	2,06
UK	UNIV CAMBRIDGE	7438,6	1,91
SE	LUNDS UNIV	2115,2	1,82
CH	ETH ZURICH	3109,0	1,66
UK	UNIV OXFORD	4934,9	1,65
UK	IMPERIAL COLL LONDON	3250,4	1,64
DE	UNIV HEIDELBERG	2127,8	1,61
PL	WARSAW UNIV	2569,7	1,56
DE	TECH UNIV MUNCHEN	2644,3	1,54
DE	LUDW MAX UNIV MUNCHEN	2360,7	1,51
NL	LEIDEN UNIV	2075,2	1,43
FR	UNIV PARIS XI SUD	5580,3	1,36
IT	UNIV ROMA SAPIENZA	3637,4	1,29
NL	UNIV AMSTERDAM	2442,3	1,25
DK	KOBENHAVNS UNIV	2320,8	1,22
DE	UNIV BONN	2124,1	1,22
IT	UNIV PADOVA	2724,6	1,21
UK	UNIV COLL LONDON	2512,8	1,19
FR	UNIV GRENOBLE I	2129,3	1,17
FR	UNIV PARIS VI	3823,1	1,15

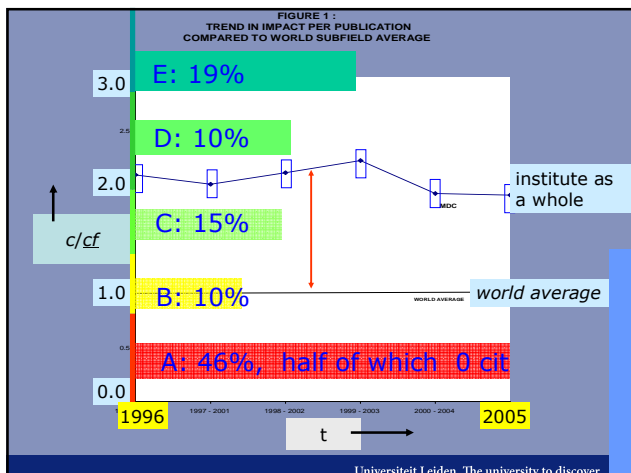
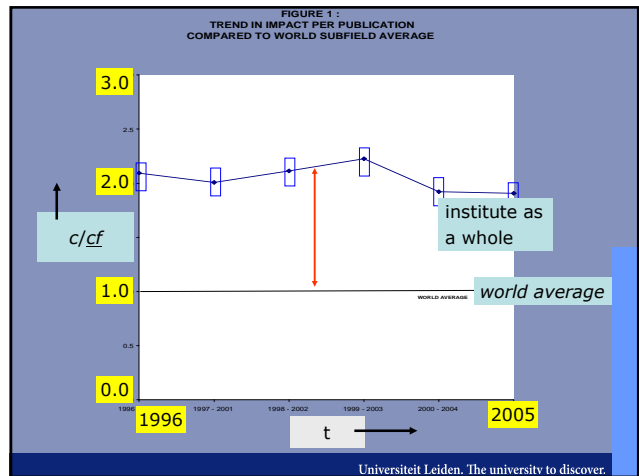
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**Table 2.1: Bibliometric analysis of a medical research institute, 1996 – 2005**

	<i>P</i>	<i>C</i>	<i>c</i>	<i>p</i> <sub>0</sub>	<i>c/c<sub>f</sub></i>	<i>c/c<sub>f</sub></i>	<i>c<sub>i</sub>/c<sub>f</sub></i>	<i>SC</i>
1996-2005	2,283	58,077	25.44	16	1.22	2.01	1.64	16
1996-2000	1,079	12,334	11.43	30	1.23	2.09	1.71	19
1997-2001	1,125	13,340	11.86	26	1.22	2.01	1.65	19
1998-2002	1,130	13,856	12.26	25	1.28	2.11	1.65	18
1999-2003	1,174	16,273	13.86	23	1.32	2.23	1.69	17
2000-2004	1,174	14,641	12.47	24	1.17	1.92	1.64	19
2001-2005	1,204	15,099	12.54	23	1.16	1.91	1.65	19



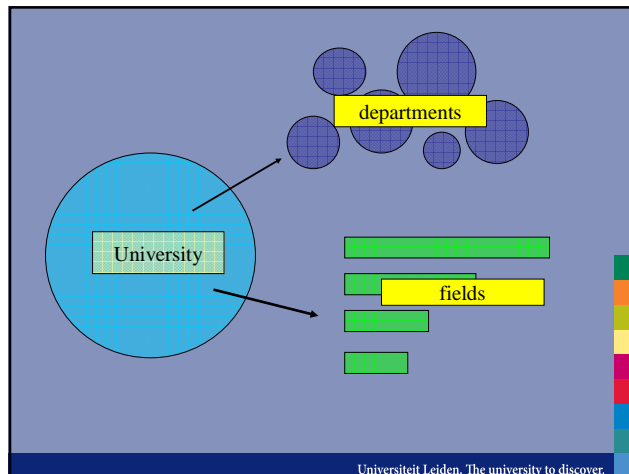
$c/c_f \leq 0.80$ :	performance significantly below internat. average, class A;
$0.80 < c/c_f \leq 1.20$ :	performance about internat. average, class B;
$1.20 < c/c_f \leq 2.00$ :	performance significantly above internat. average, class C;
$2.00 < c/c_f \leq 3.00$ :	performance in internat. perspective is very good, class D;
$c/c_f > 3.00$ :	performance in internat. perspective is excellent, class E.

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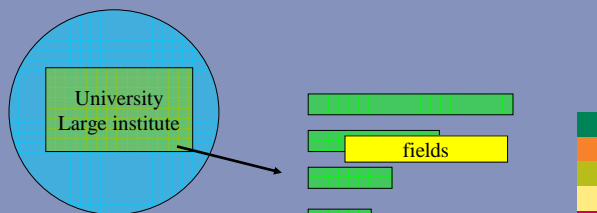
**TABLE 4: BIBLIOMETRIC INDICATORS FOR MAIN FIELDS**

University	$P^*$	Rank	$C^*$	Rank	$CPP/FCSm$	Rank	$CPP/FCSm$	Rank
<b>PHYSICS AND ASTRONOMY</b>								
UNIV HEIDELBERG	1.389	83	14.053	54	1.79	71	2.484	59
BJM UNIV WURZBURG	787	183	4.320	194	1.29	168	1.012	177
EK UNIV TUBINGEN	923	154	4.867	177	1.04	237	961	188
FAKIE UNIV BERLIN	1.096	123	5.089	171	1.00	247	1.099	164
GA UNIV GOTTINGEN	1.067	129	4.927	176	0.90	264	963	187
HUMBOLDT UNIV BERLIN	1.248	102	7.574	122	1.18	196	1.476	130
JG UNIV MAINZ	1.331	88	11.949	69	1.83	69	2.435	64
LMU UNIV MUNICHEN	1.597	61	13.337	56	1.58	102	2.522	58
MED HOCHSCHULE HANNOVER	0	-	-	-	-	-	-	-
RFW UNIV BOHN	1.517	68	10.921	76	1.33	157	2.017	81
RUHR UNIV BOCHUM	1.616	58	7.939	117	1.04	238	1.682	110
TECH UNIV MUNICHEN	1.955	40	11.878	71	1.38	140	2.700	56
UNIV AACHEN (RWTH)	1.116	119	9.525	92	1.75	77	1.951	87
UNIV FREIBURG	874	165	6.043	149	1.34	152	1.175	160
UNIV HAMBURG	1.465	74	9.186	96	1.21	186	1.779	98
UNIV KARLSRUHE (TH)	1.608	59	16.144	49	2.04	44	3.279	46
UNIV KONSTANZ	407	277	2.326	265	1.23	181	501	264
UNIV MUNSTER	762	190	4.610	185	1.36	146	1.037	172
LARGE GERMAN UNIVERSITIES	29.623	-	169.699	-	1.22	-	36.133	-

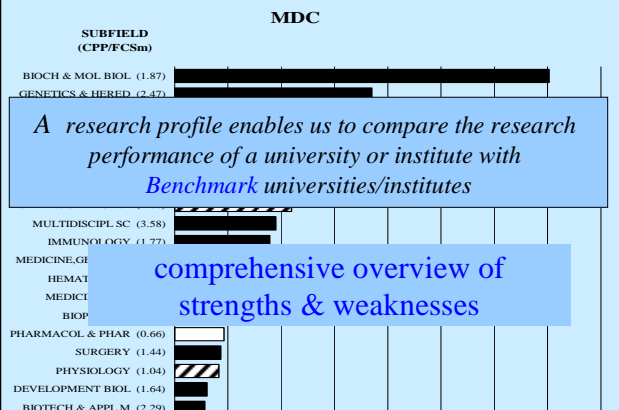
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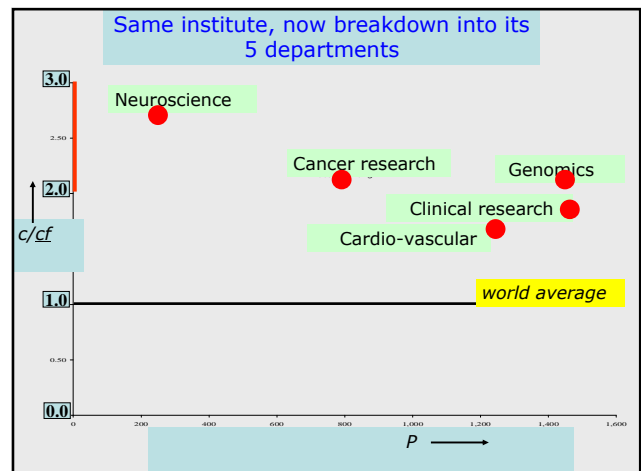
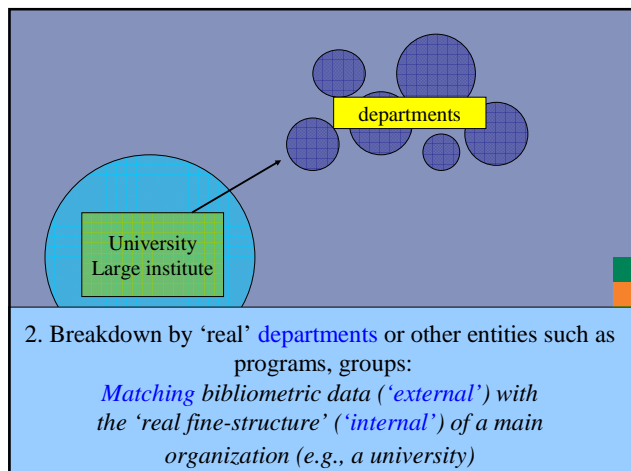
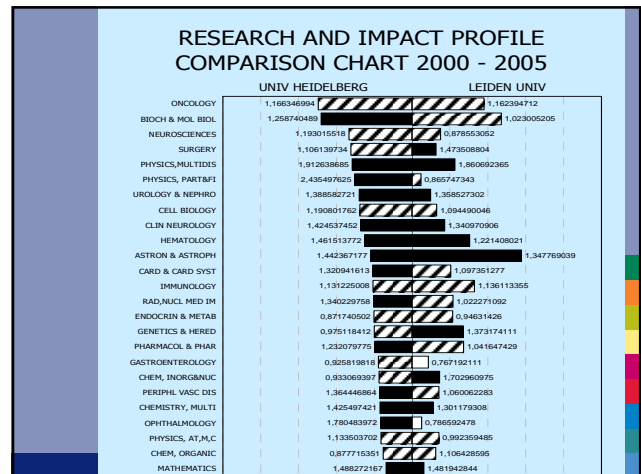
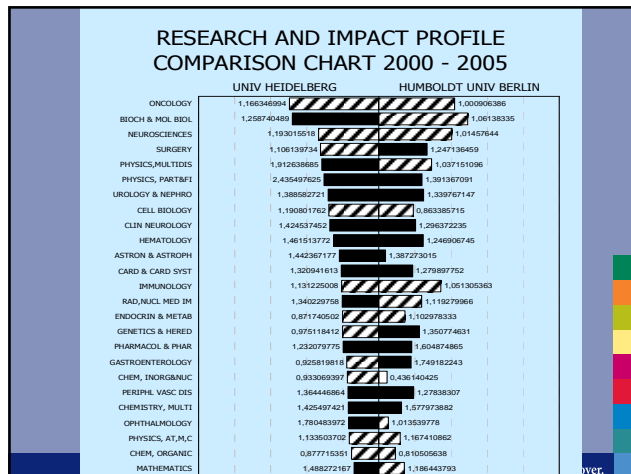


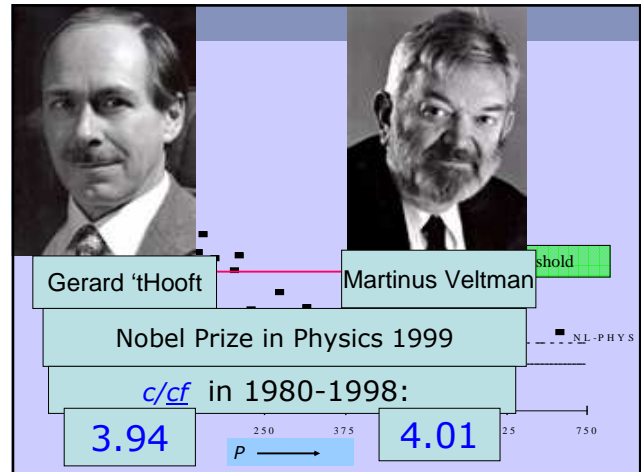
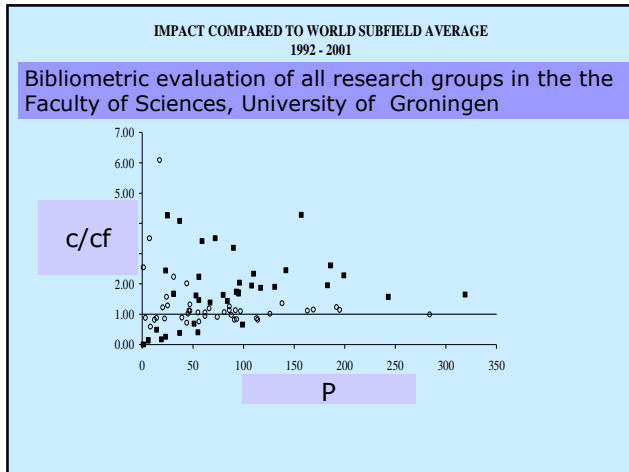
1. Breakdown by 'internationally standardized' research fields: 'research profile'



**PUBLICATIONS AND IMPACT PER SUBFIELD 1992 - 2000**







$c/cf$  is still an average value

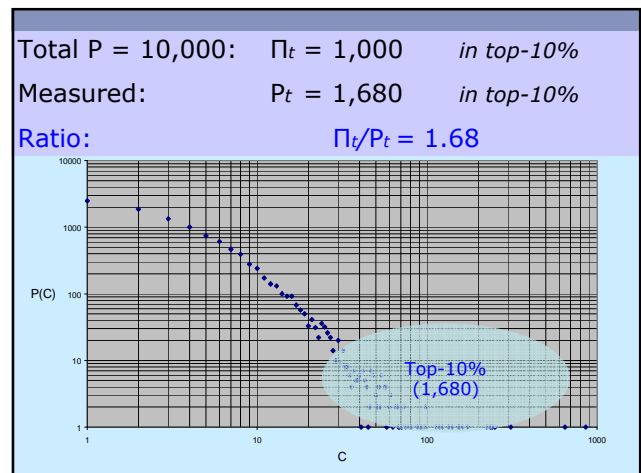
Experience explains what it means, for instance,  $c/cf = 2.5$  is very good...

Is it possible to find a more 'self-explaining' impact parameter?

Yes, by answering the question 'do these publications belong to the top-10% of the worldwide impact distribution function of the field?'

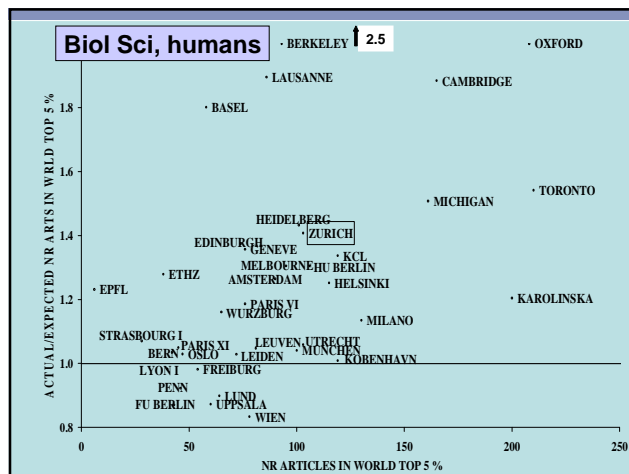
Calculate  $\Pi_t/P_t$

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Research Unit	P 0203	Ptop 5%	E(Ptop 5%)	A/E(Ptop 5%)
Biology	438	30	21.8	1.37
Chemistry	344	35	17.2	2.03
Earth Sciences	104	9	5.3	1.69
Engineering	186	20	9.3	2.15
Mathematics and Computer Science	181	16	8.9	1.80
Medicine	1.432	95	71.8	1.32
Pharmacy	308	17	15.5	1.10
Physics	368	21	18.2	1.15
Social Sciences	151	10	7.5	1.33
<b>Uppsala University</b>	<b>3.190</b>	<b>228</b>	<b>159,5</b>	<b>1,43</b>

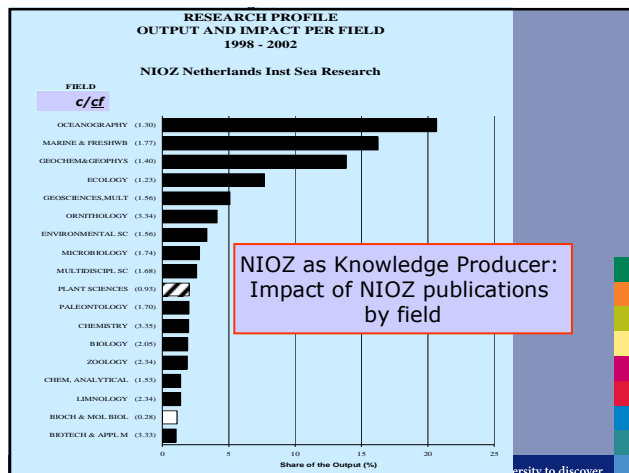
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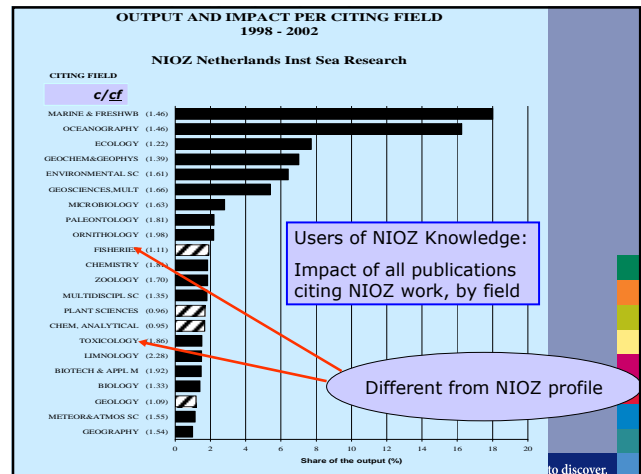
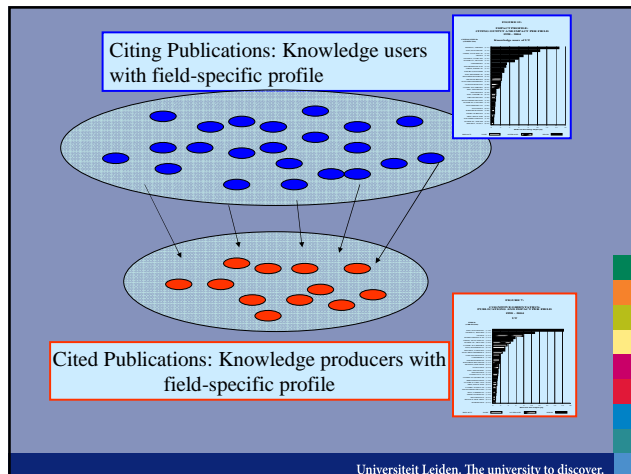
#### LUMC examples:

	P	$c/cf > 2.5$
Rheumatology	92	3.34
T-cell immune response	88	2.73
Oncological surgery	106	3.74
Infection diseases	26	3.63
Clinical epidemiology	190	2.59
Tumour genetics	93	2.75

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Peer ratings versus crown indicator value for 306 departments in physics, chemistry, and biology

rating	Q	CPP/FCSm				Σ
		very low 0.0- <0.5	low 0.5- <1.0	high 1.0- <1.7	very high >1.7	
unsatisfactory	2	3	7	0	0	10
satisfactory	3	6	51	31	3	91
good	4	1	27	80	29	137
excellent	5	0	6	26	36	68
		10	91	137	68	306

from: H.F. Moed 2005

More concrete objections:

- \* Field-definition and therefore the denominator **cf** (**FCSm**) may be inappropriate;
- \* Time-lag ('older situation');
- \* Main stream work will be cited better than 'risky', new work

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## Science mapping based on co-word analysis

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### Step 1 (crucial!):

field definition → set of publications on the basis of journals, keyword-selection, special databases

*Major fields (e.g., neuroscience, condensed matter physics) cover about 50,000 publ/y)*

VOLUME 88, Number 13 PHYSICAL REVIEW LETTERS 1 April 2002

### Truncation of *Power Law* Behavior in “*Scale-Free*” Network Models due to *Information Filtering*

We formulate a general model for the *growth* of *scale-free networks* under *filtering information* conditions—that is, when the *nodes* can process information about only a subset of the existing nodes in the network. We find that the *distribution* of the number of *incoming links* to a node follows a *universal scaling* form, i.e., that it decays as a *power law* with an *exponential truncation*

### Step 3:

- \* The parsing procedure will yield many thousands of keywords → concepts
- \* These concepts are ranked by frequency
- \* We take the top-200:  $w_1, w_2, \dots, w_{200}$
- \* We encode each of the 50,000 publications with a binary string, e.g.,  $p_1 = [1, 1, 0, 0, \dots, 0]$

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Publications encoded as a string of concepts (keywords): 'DNA-coding of publications'

	w1	w2	w3	w4	w5	.....
p1	1	1	1	1	1	
p2	0	0	1	0	0	
p3	0	0	0	0	0	
p4	0	0	0	0	0	
.						
.						

With matrix-algebra > concept- (w1,...w5) correlation

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Calculation of word-correlations

$$P^T(w) \times P(w)$$

1...1...1...0  
1...0...0...0  
1...1...0...0  
1...1...1...0  
1...0...0...0

1...1...1...1...1  
1...0...1...1...1  
1...0...0...1...0  
0...0...0...0...0

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$$P(w) \times P^T(w) = C(P)$$

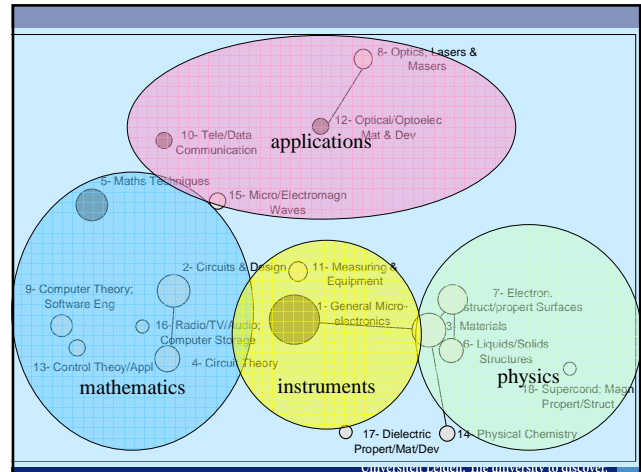
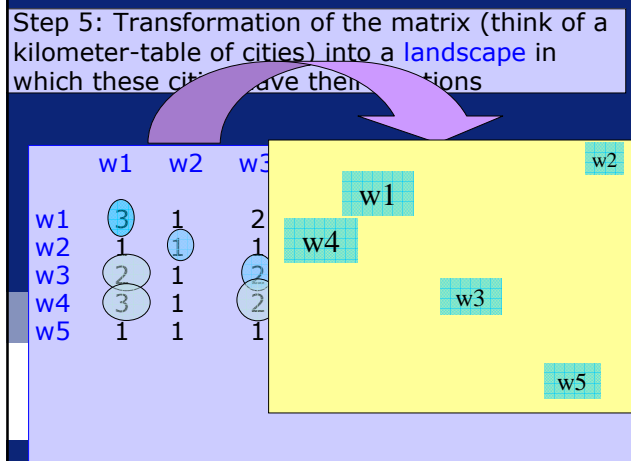
$$P^T(w) \times P(w) = C(w)$$

	w1	w2	w3	w4	w5
w1	3	1	2	3	1
w2	1	1	1	1	1
w3	2	1	2	2	1
w4	3	1	2	3	1
w5	1	1	1	1	2

Step 5

Transformation of the matrix (think of a kilometer-table of cities) into a **landscape** in which these cities have their locations

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### Mapping Excellence in Science and Technology

#### Top rankings in this field

The top rankings are retrievable at different levels of aggregation. Apart from a worldwide ranking together and for each of these states individually. The results are generated at the departmental level.

Select a field: Genetics

Select a level of aggregation: EU&AS

Show departments? no

Use cleaned data? yes

Sort on: P10 Show top: 10 Required number of papers: 20

**Recalculate**

*Note that it may take some time before the page gets refreshed while recalculating.*

No ranking calculated, yet.

Select the required level of aggregation (country or country aggregate), sort criterion, number of rows to display and whether or not to aggregate the rankings to department level.

Then press the **Recalculate** button.

### Genetics

Ranking	Country	City	Organization	P	CX	P10	CPP	CPP/FCSm	PS	PN
1	UNITED KINGDOM	LONDON	UNIV LONDON	7021	39164	343	5.58	1.72	20.4%	62.3%
2	UNITED KINGDOM	OXFORD	UNIV OXFORD	2674	19543	207	7.31	2.13	20.4%	63.1%
3	UNITED KINGDOM	CAMBRIDGE	UNIV CAMBRIDGE	2102	15060	131	7.16	1.97	20.0%	62.3%
4	FRANCE	PARIS	UNIV PARIS 06	1905	12536	117	6.58	1.69	20.6%	69.7%
5	UNITED KINGDOM	EDINBURGH	UNIV EDINBURGH	1601	9336	97	5.63	1.68	19.1%	61.1%
6	NETHERLANDS	LEIDEN	UNIV LEIDEN	1490	10706	94	7.19	1.88	21.9%	57.7%
7	FRANCE	PARIS	UNIV PARIS 06	1588	10284	91	6.48	1.96	19.3%	62.5%
8	NETHERLANDS	ROTTERDAM	ERASMUS UNIV	1292	9684	89	7.42	2.11	21.6%	57.9%
9	SWEDEN	STOCKHOLM	KAROLINSKA INST	1690	9293	85	5.50	1.76	24.5%	64.2%
10	FRANCE	PARIS	INST PASTEUR	1216	8417	81	6.92	1.64	20.7%	67.0%
11	ITALY	MILAN	UNIV MILAN	1627	7730	74	4.75	1.54	23.6%	62.3%
12	SWITZERLAND	GENEVA	UNIV GENEVA	862	6784	72	7.87	1.81	20.7%	57.7%
13	GERMANY	HEIDELBERG	EUROPEAN MOLEC BIOL LAB	507	5450	71	10.75	2.03	20.8%	62.5%
14	FINLAND	HELSINKI	UNIV HELSINKI	1683	8665	69	5.15	1.79	23.7%	65.1%
15	NETHERLANDS	AMSTERDAM	UNIV AMSTERDAM	1195	6854	69	5.74	1.62	23.0%	68.5%
16	GERMANY	HEIDELBERG	UNIV HEIDELBERG	934	6195	63	5.56	1.66	23.9%	62.4%
17	GERMANY	MUNICH	UNIV MUNICH	1369	6986	61	5.10	1.61	21.6%	64.4%
18	FRANCE	PARIS	UNIV PARIS 07	1095	8032	60	7.34	2.18	18.1%	61.0%
19	NETHERLANDS	UTRECHT	UNIV UTRECHT	1126	7495	59	6.66	1.87	19.9%	68.7%
20	UNITED KINGDOM	MANCHESTER	UNIV MANCHESTER	1252	6121	55	4.89	1.64	22.4%	65.3%

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