THE COST-EFFECTIVENESS OF PHYSICS JOURNALS

A survey of more than 200 journals shows that their cost-effectiveness, as measured by the ratio of the cost per printed character to the frequency with which articles are cited, varies by three orders of magnitude.

Henry H. Barschall

The rapid increase in the prices of physics journals has forced many physics libraries, in the face of static budgets, to cancel some of their subscriptions. Decisions on cancellations are usually based on the research interests of the users of the library, but the decision-making process can be improved if a quantitative measure of the cost-effectiveness of the journals is available. An often-used measure is the cost per printed character; another is the frequency with which articles in the journal are cited, often referred to as the "impact." The ratio of these two measures is perhaps the best indicator of a journal's cost-effectiveness.

In an earlier article in this magazine (December 1986, page 34), I compared the cost of physics journals with that of mathematics and philosophy journals. I concluded that the cost per printed character varied widely within each field, but that the average cost per character was about the same in all three fields. The article included data on the cost per character for some physics journals in 1985. Barbara Meyers did a similar study for optics periodicals and published the results in the May 1988 issue of *Optic News*. Sidney Abrahams and Richard Matula report the cost per character for crystallography journals in an article in the July 1988 issue of *Acta Crystallographica*. They also develop a measure of the comprehensiveness of journals, using papers presented at international scientific congresses as a standard.

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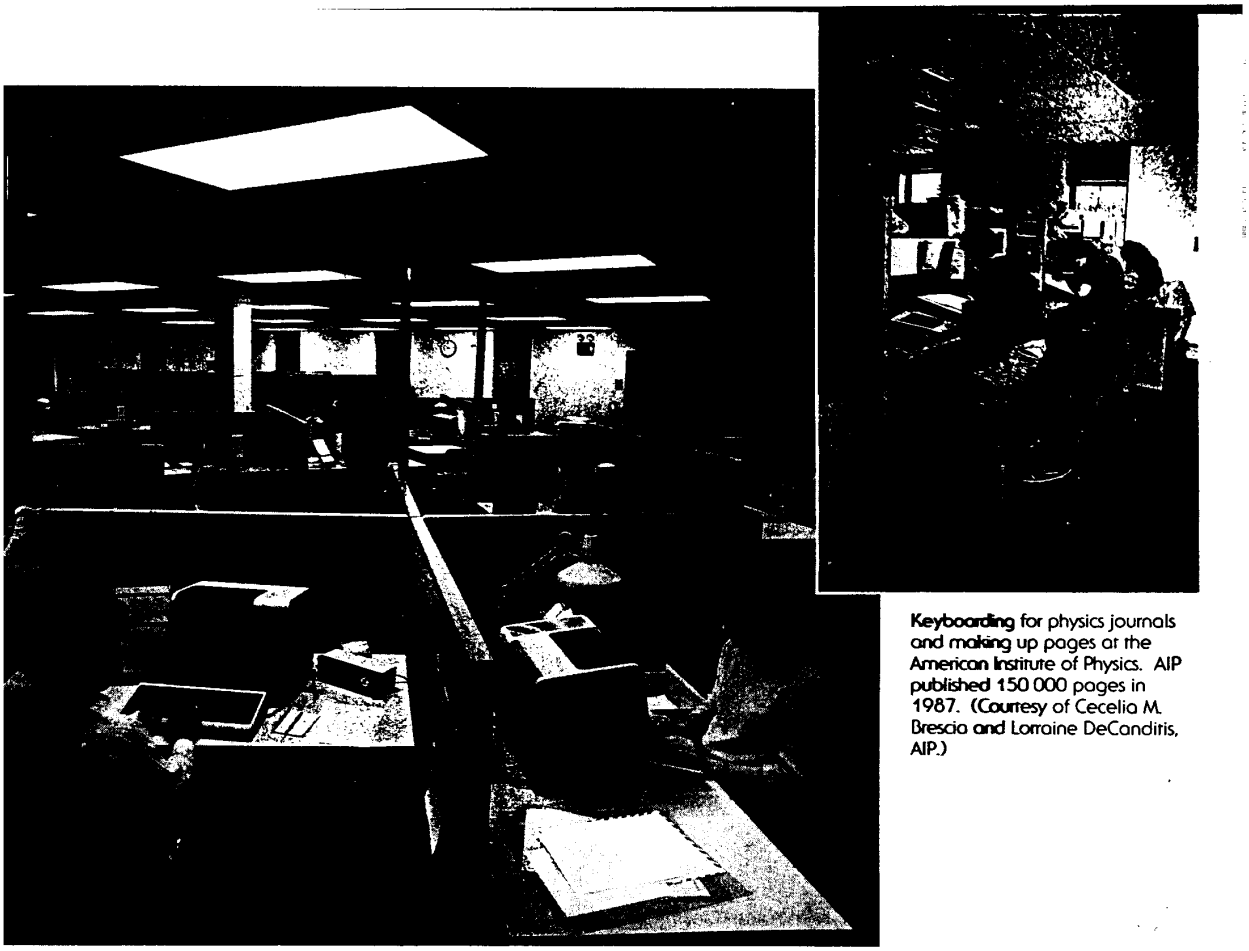
When the physics library at the University of Wisconsin, Madison, needed to cancel more journal subscriptions to stay within its budget, I decided to survey the cost and cost-effectiveness of all the physics journals to which there was easy access. John R. Arrington and I collected the data for the survey, and table 1 summarizes them for a few subfields and types of journals. In each group the journals are listed in order of increasing cost per character for 1987. The "impact" of a journal is defined as the average number of citations in 1986 of articles published in that journal in 1984 and 1985, according to the 1986 *Science Citation Index*, which is published by the Institute for Scientific Information, in Philadelphia. A low number in the last column, which shows the ratio of the cost per 1000 characters to the impact, corresponds to good cost-effectiveness. The complete survey, which covers more than 200 journals, appears in the July 1988 issue of the *Bulletin of the American Physical Society*, along with detailed explanations of how we chose the journals and how we determined the numbers given.

Results of survey

The cost per 1000 characters varies from 0.39 cents to 31 cents, that is, by a factor of about 80, and the ratio of cost to impact varies from 0.063 to 54, that is, by a factor of 850. A high cost per character usually indicates a small number of subscribers and hence of readers. Table 1 shows that the variations are similar among letters journals, review journals and journals in the various subfields. For example, among letters journals the cost per character varies by a factor of 23 and the ratio of cost to impact by a factor of 130. Among the journals in condensed matter



Keyboarding for physics journals and making up pages at the American Institute of Physics. AIP published 150 000 pages in 1987. (Courtesy of Cecelia M. Brescia and Lorraine DeCanditis, AIP.)

physics the variation is a factor of 43 for the cost per character and more than 200 for the ratio of cost to impact.

The cost per character does not vary greatly for journals published by the same publisher. For the journals covered in our survey, table 2 lists the publishers in order of increasing cost per character. The table includes only publishers that publish more than one journal covered in the survey. Excluding translation journals, which have a quite different cost basis, the average cost per character varies by a factor of 38, and the average ratio of cost to impact varies by a factor of 240. All the publishers whose journals have low average costs per character or low ratios of cost to impact are scientific societies or associations, while the publishers whose journals have high costs per character or high ratios of cost to impact are commercial firms.

Translation journals are listed separately in the table. The cost per character in these journals varies by a factor of about 9 among the three major publishers. The *Citation Index* includes few translation journals; hence the table does not list their impact.

Causes of the library crisis

The crisis now faced by all science libraries, and particularly physics libraries, is caused by the rapid increase of subscription prices, an increase much greater than that of the cost-of-living index. From 1987 to 1988 the total subscription cost of all the journals in our survey, excluding translation journals, went up by 21 percent, while the total cost of translation journals increased by 13 percent. A frequently mentioned explanation of the large increase is the weak dollar. Several of the most expensive physics journals have prices quoted in Dutch guilders. In 1979 the Dutch guilder was worth 50 cents. Its value dropped to 32 cents by 1984, but it then recovered, reaching 45 cents in 1987 and 52 cents now. Although in the past two years the exchange rate has caused subscription prices to increase, the rate is not very different from what it was a decade ago, when the libraries did not suffer.

While fluctuations in exchange rates have recently increased the cost of foreign journals, the cost of US journals has also increased rapidly. There are several reasons for this:

▷ Production and distribution costs, which depend on the cost of labor, paper and postage, have increased more rapidly than the general cost of living.

▷ The number of pages published has increased dramatically for many journals. *Applied Physics Letters*, for example, published 1600 pages in 1977 and 4300 pages in 1987; the *Journal of Applied Physics* grew from 5500 pages in 1977 to 10 800 pages in 1987; *Physical Review* grew by 75% in 10 years.

▷ The number of subscriptions has dropped steadily for almost all physics journals. Editorial and production costs, which represent about two-thirds of total publication expenses, are independent of the number of subscriptions; hence publishers have to raise prices to cover the fixed costs.

▷ The publishers of most US physics journals have reduced or eliminated page charges. *Physical Review*, for example, dropped its page charges from $85 in 1983 to $25 today. The *Journal of Mathematical Physics* and the *Review of Scientific Instruments* eliminated page charges entirely. Publishers have to raise subscription prices to

Table 1. Library subscription costs

Journal	Publisher	Price 1987 (dollars/year)	Price 1988 (dollars/year)	Pages 1987	Cost per 1000 characters (cents)	Impact (citations per article after two years)	Ratio of cost to impact
Letters journals							
Appl. Phys. Lett.	AIP	330	425	4 329	1.1	3.5	0.31
Phys. Rev. Lett.	APS	470	625	5 927	1.3	6.5	0.19
Opt. Lett.	OSA	180	200	1 077	2.7	2.8	1.0
Solid State Commun.	Pergamon	780	860	4 389	2.8	1.6	1.7
Geophys. Res. Lett.	AGU	245	262	1 270	3.0	2.0	1.5
Europhys. Lett.	EPS	416	500	2 784	3.4	—	—
Phys. Lett. B	North Holland	1978	2542	8 370	4.7	3.5	1.3
Phys. Lett A	North Holland	742	953	3 052	4.9	1.1	4.4
Opt. Commun.	North Holland	582	758	1 899	5.9	1.4	4.3
Lett. Math. Phys.	Reidel	192	251	741	6.7	0.7	10.0
Mod. Phys. Lett. A	World Scientific	250	380	1 003	6.9	—	—
Acoustics Lett.	Parjon	93	100	208	8.7	—	—
Spectrosc. Lett.	Marcel Dekker	375	375	1 019	25.7	1.0	25.2
Review journals							
Rev. Mod. Phys.	APS	160	170	1 360	1.7	27.0	0.063
Prog. Theor. Phys.	Phys. Soc. Jpn.	380	465	4 100	2.4	1.8	1.4
Fortschr. Phys.	Akademie Verlag	175	190	859	4.5	1.3	3.4
Rep. Prog. Phys.	IOP	375	430	1 720	5.1	6.7	0.77
Prog. Nucl. Mag. Res. Sp.	Pergamon	145	190	624	6.4	7.5	0.85
Prog. Surf. Sci.	Pergamon	275	330	1 114	6.8	3.6	1.9
Phys. Rep.	North Holland	1607	2383	5 147	6.9	7.0	1.0
Adv. Phys.	Taylor & Francis	300	300	850	8.7	7.0	1.2
Prog. Quant. Electron.	Pergamon	135	150	346	9.3	1.9	5.0
Atomic physics							
Phys. Rev. A	APS	510	715	11 224	0.66	2.4	0.28
J. Phys. B	IOP	715	840	7 574	2.2	2.7	0.82
Z. Phys. D	Springer	516	928	1 528	5.8	—	—
Opt. Quant. Electron.	Chapman & Hall	245	245	510	10.0	0.6	16.0
Hyperfine Interact.	Baltzer	1010	1213	2 690	11.0	1.1	10.1
Condensed matter physics							
Phys. Rev. B	APS	990	1305	19 810	0.72	3.3	0.22
J. Phys. C	IOP	995	1130	6 430	3.1	2.2	1.5
Phys. Status Solidi A	Akademie	790	873	5 189	3.5	0.6	5.8
Phys. Status Solidi B	Akademie	789	875	4 817	3.8	0.7	5.2
Nuovo Cimento D	Soc. Ital. Fisica	330	346	1 500	5.5	0.6	9.7
Z. Phys. B	Springer	700	1106	2 155	5.6	1.8	3.2
Solid State Ionics	North Holland	473	767	1 372	6.8	1.0	6.6
J. Phys. Chem. Solids	Pergamon	600	660	1 254	7.6	1.0	7.7
J. Magn. & Magn. Mater.	North Holland	1493	1716	3 652	9.0	1.4	6.3
J. Nucl. Mater.	North Holland	1225	1353	2 251	9.7	1.2	8.5
Phys. Chem. Liq.	Gordon & Breach	294	324	332	31.0	0.7	45.0
Nuclear physics							
Phys. Rev. C	APS	365	385	5 009	1.1	2.0	0.52
Nucl. Sci. Eng.	ANS	320	320	1 039	5.1	0.6	9.2
J. Phys. G	IOP	440	515	1 894	5.5	1.5	3.7
Nucl. Phys. A	North Holland	3000	3885	11 370	7.4	2.5	3.0
Z. Phys. A	Springer	712	860	1 517	8.1	1.6	4.9
Nuovo Cimento A	Soc. Ital. Fisica	550	576	1 600	9.0	0.6	15.5
Particle physics							
Phys. Rev. D	APS	550	675	7 920	1.0	2.6	0.38
Z. Phys. C	Springer	1099	1030	2 600	7.2	2.0	3.7
Nucl. Phys. B	North Holland	3000	3 885	11 370	7.4	4.9	1.5
Nuovo Cimento A	Soc. Ital. Fisica	550	576	1 600	9.0	0.6	15.5
Applied physics							
J. Appl. Phys.	AIP	580	725	10 808	0.76	1.8	0.43
Jpn. J. Appl. Phys.	Phys. Soc. Jpn.	506	710	4 345	1.7	0.4	4.0
J. Phys. D	IOP	355	420	1 694	3.2	0.9	3.4
Appl. Phys. A	Springer	516	648	1 010	8.6	1.7	5.2
Appl. Phys. B	Springer	425	538	780	9.2	1.3	7.3
Instrumentation							
J. Vac. Sci. Technol. A	AIP-AVS	450	375	3 594	1.8	2.1	0.88
J. Phys. E	IOP	255	290	1 548	2.0	0.7	2.9
Rev. Sci. Instrum.	AIP	345	395	2 418	2.0	1.1	1.9
J. Vac. Sci. Technol. B	AIP-AVS	425	375	1 832	3.4	2.9	1.2
Exp. Tech. Phys.	VEB	75	90	414	4.2	—	—
Nucl. Instrum. Methods B	North Holland	2112	2240	5 032	6.8	1.1	6.4
Nucl. Instrum. Methods A	North Holland	2640	2800	6 290	6.8	0.5	13.0
Laser Part. Beams	Cambridge U. P.	150	165	413	8.2	1.1	7.5
Part. Accel.	Gordon & Breach	252	276	326	22.0	—	—

Table 2. Subscription costs, by publisher

Publisher	Number of journals	Average cost per 1000 characters (cents)	Average ratio of cost to impact
AAS	2	0.52	0.12
APS	6	1.1	0.28
IEEE	4	1.4	1.1
OSA	4	1.5	0.74
AIP	11	1.9	1.1
AGU	3	2.1	0.74
Phys. Soc. Jpn.	3	2.1	2.2
Polish Scientific	2	3.1	6.6
Int. Union Crystallogr.	3	3.5	2.8
IOP	10	3.5	1.9
Akademie Verlag	2	3.7	5.5
Royal Soc.	2	4.8	2.9
World Scientific	2	5.2	—
Academic	4	6.2	4.5
Pergamon	15	6.8	6.6
Cambridge U.P.	3	7.2	8.4
Springer	9	7.4	4.0
North Holland	22	7.5	5.7
Reidel	3	7.8	10.0
Taylor & Francis	6	7.8	3.5
Soc. Ital. Fisica	4	7.9	12.4
Plenum	7	8.5	11.1
Elsevier	3	10.2	6.4
Gordon & Breach	11	19.6	29.5
Translation journals			
AIP	13	8.3	—
Plenum	11	14.1	—
Allerton	2	16.8	—

make up for lost page-charge income.

Another development that has contributed to the financial crisis is the publication of new journals. The current financial problems of libraries have slowed but not stopped this phenomenon. Although some publishers maintain that the new journals are cheaper than the existing journals, the measure usually considered is the cost of an annual subscription, not the cost per character.

Solutions to the crisis

The present situation is unstable. When libraries are forced to cancel subscriptions, publishers have to raise prices, forcing libraries to cancel more subscriptions. What can publishers, subscribers or authors do to help the libraries?

Libraries would like to see an increased reliance on page charges, while authors would not. Authors feel that their limited research budgets should not help libraries subscribe to more expensive journals that don't have page charges. Editors' opinions about page charges depend on whether or not their journals have competitors without page charges; the editors are concerned they will lose their best authors if the journals charge. Astrophysicists appear to be most willing to pay page charges, because all the best astrophysics journals require payment; even the European journal *Astronomy and Astrophysics* has page charges. As a consequence, American Astronomical Society journals have the lowest cost per character. Particle theorists, on the other hand, are the most unwilling to publish in journals with page charges. With the exception of *Astronomy and Astrophysics*, page charges for physics journals are almost entirely a practice of US scientific societies, such as the Institute of Electrical and Electronics Engineers and the American Institute of Physics and its member societies. Publication committees of AIP and its member societies spend much time arguing about whether page charges should be increased, decreased or eliminated. Page charges usually result in a lower cost per character. An exception is *Nuclear Science and Engineering*, which has the highest page charge—$165—and a relatively high cost per character.

Another suggestion is that journals could achieve great savings if they accepted manuscripts in machine-readable form. But as Abrahams and Matula discuss in their *Acta Crystallographica* article, the experience of *Physical Review*, which accepts such "compuscripts," indicates that these savings are likely to be small or absent. They estimate the total cost saving with compuscripts to be less than 15 percent. When preparing compuscripts, authors frequently do not follow instructions closely enough for their material to run smoothly on the journal's computer, and the corrections are often more time-consuming than the ordinary routine. Apparently more cost-effective than compuscripts is machine reading of typed manuscripts. AIP operates two Kurzweil optical character recognition systems on both day and night shifts. (See PHYSICS TODAY, June, page 56.) These machines read typewritten text, but not equations.

Another suggestion often made is for editors to accept fewer papers and so reduce the number of pages published. There are several reasons why that does not help. The editorial cost of rejecting a paper is greater than that of accepting a paper, especially for society journals, where authors can pursue various appeals. Even if the paper is rejected, the author usually publishes it in another journal, often one with a higher cost per character and lower acceptance standards. As a result, the cost to the libraries is increased. High rejection rates do not necessarily prevent the growth of a journal. *Physical Review Letters*, which probably has the highest rejection rate of any physics journal, has more than doubled in size in the last decade.

Some physicists suggest that we go to electronic rather than printed journals. That would greatly increase the cost, because there is at present no cost-effective way to handle graphics. Only a few physicists advocate discontinuing the printing of journals.

There is no simple solution, but authors can help physics libraries by publishing their papers in journals that have a low cost per character. In general, articles in such journals also have a greater "impact," so that authors too will benefit by publishing in them. ■