

# From The Science of Science to Scientometrics. Visualizing the History of Science with *HistCite* Software

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## Abstract

While ISSI was founded in 1993, scientometrics and bibliometrics are now at least half a century old. Indeed, the field can be traced to early quantitative studies in the early 20<sup>th</sup> Century. In the thirties, it evolved to the "science of science." The publication of J. D. Bernal's *Social Function of Science* in 1939 was a key transition point but the field lay dormant until after World War II, when DJD Price's books *Science Since Babylon* and *Little Science, Big Science* were published in 1961 and 1963. His role as the "father of scientometrics" is clearly evident by using the *HistCite* software to visualize his impact as well as the subsequent impact of the journal *Scientometrics* on the growth of the field. *Scientometrics* owes its name to V. V. Nalimov, the author of *Naukometriya*, and to Tibor Braun who adapted the neologism for the journal. The primordial paper on citation indexing by Garfield which appeared in *Science* 1955 became a bridge between Bernal and Price. The timeline for the evolution of scientometrics is demonstrated by a *HistCite* tabulation of the ranked citation index of all the 100,000 references cited in the 3,000 papers citing Price.

## Keywords

history of scientometrics; etymology of science; Derek J.D. Price; V. V. Nalimov; J. D. Bernal; Science of Science; *HistCite*; algorithm; historiography; bibliometrics.

## Introduction

When Henk Moed asked me to present a keynote address to this Eleventh International Conference of the International Society for Scientometrics and Informatics (ISSI) I had mixed feelings. I had previously planned to participate by simply describing my current work on algorithmic historiography. The paper I originally planned to submit was an up-to-date description of the *HistCite* system (<http://www.histcite.com/>). Briefly stated, *HistCite*<sup>™</sup> is a software system which generates chronological maps of bibliographic collections resulting from subject, author, institutional or source journal searches of the *ISI Web of Science*.<sup>®</sup> *WoS* export files are created in which all cited references for each source document are captured. The software generates chronological historiographs highlighting the most-cited works in the retrieved collection. Other listings include rankings by author, journal, institution, or vocabulary.

But Henk thought that this might be a good chance to provide the current ISSI membership with some personal reflections on the origins of scientometrics, especially as it is now two decades since the first ISSI conference held in Belgium in 1987 and 14 years since ISSI was founded in Berlin. It is noteworthy that the term "scientometrics" itself was not included in the title of the 1987 meeting which was called the First International Conference on Bibliometrics and Theoretical Aspects of Information Retrieval. Twenty years earlier, Alan Pritchard had coined the term bibliometrics in his paper on statistical bibliography which defined the term bibliometrics. (Pritchard, 1969).

Most of us have been exposed to the macro history of scientometrics. We recognize names like Derek de Solla Price and V.V. Nalimov and perhaps earlier pioneers in measurement such as Alfred Lotka and George K. Zipf. If you search the *Web of Science* for the past century, these names will pop up very quickly. But when you search year-by-year you obtain a very different micro-perspective. Today, I would like to recall for you aspects of the micro and macro impact of Derek Price's work, since he is usually considered "the father of Scientometrics." But this simplistic metaphor for the history and evolution of his role in scientometrics, does not adequately reflect the influences of earlier statistically and quantitatively oriented scholars.

In the foreword to the second edition of "Little Science, Big Science," (Merton and Garfield, 1986) Robert K. Merton and I identified Derek as the father of scientometrics because he was perceived, in the western world, to have made the greatest impact on the use of quantitative indicators in formulating science policy. The first edition of the 1963 book was aptly identified later as a *Citation Classic* (Price, 1983) but at the time the book was written, Derek had not even encountered the term scientometrics, which was coined by the Russian mathematician-philosopher-polymath, V. V. Nalimov. "Scientometrics" is the English translation of the title word of Nalimov's classic monograph *Naukometriya*,<sup>1</sup> (Nalimov and Mul'chenko, 1973) which was relatively unknown to western scholars even after it was translated into English. Without access to the internet and limited distribution, it was rarely cited. However, the term became better known once the journal *Scientometrics* appeared in 1978. Stephen Bensman in a tribute to Tibor Braun recently reminded us how the journal became a bridge between the East and West. (Bensman & Kraft, in press)

Let me remind you of some historical facts. Price's "*Science Since Babylon*" (Price 1986) was published six years after my 1955 paper in *Science* (Garfield, 1955). The first edition of *Little Science, Big Science* appeared two years later in 1963. The opening page is called a "prologue to a science of science." If Derek was aware of my paper, he did not cite it then. Even in his classic 1965 *Networks* paper in *Science* (Price, 1965) he referred to the 1963 *Genetics Citation Project* and my 1964 *Science* paper by which time we had made personal contact (Garfield, 1964). But even earlier, in 1962, I had written to J.D. Bernal and Robert K. Merton about the experimental *Science Citation Index* which resulted from that project. I met Bernal briefly at the International Conference on Scientific Information in Washington in 1958. It was not until 1983, in his *Citation Classic* commentary (Price, 1983) cited above, that Derek notes that he was "stimulated much by Robert Merton's writings in the sociology of science, by Eugene Garfield's new book on citation indexing, and by rereading Desmond Bernal's books which had prepared my mind for the initial sensitivity that led me to this field in the first place." Of course, Derek could not have read my book at that time because it did not come out until 1979. Perhaps he should have used the term "work" instead.

In the preface to Volume 3 of my *Essays of an Information Scientist*, (Price DJD, 1980) Derek himself related how we first encountered each other when he was a member of the National Science Foundation's Science Information Council. He reports how I tried to get the NSF to support printing and distribution of the *Science Citation Index*:

*From that day to the present....I have found megavitamins for my intellectual diet on the cutting room floor of ISI's computer room. Bit by bit we have begun to understand how citations work and in the course of this, there has emerged a new sort of statistical sociology of science that has thrown light on many aspects of the authorship, refereeing, and publication of scientific research papers. The Society of Social Studies in Science now has an annual meeting devoted to this new method of understanding science that has grown, almost as an accidental by-product, from the indexing technology developed by the Institute for Scientific Information. Our initial intuitive perceptions have turned out to be correct.*

The early 4S group ultimately became the Society for the Social Studies in Science (4S) which together with ISI sponsors the annual Bernal Award. The Society's interest in scientometrics has waned considerably in recent years, perhaps in part because of the growth of ISSI which understandably is not as preoccupied with the history and sociology of science as is 4S.

The first co-citational link between Garfield and Price was made in the early sixties by the mathematical statistician, John W. Tukey (Tukey 1962). Between 1955 and 1964 he was the only author who co-cited me and Derek. Keep in mind that Tukey was not a scientometrician. Like myself at the time, he was primarily interested in helping scientists to keep in touch with the literature. He and Joshua Lederberg played a key role, especially through the Weinberg Committee report, in promoting the idea of citation indexes as a new and promising method for information retrieval. No one was then actively talking about citation indexing as a scientometric tool per se. Alan Pritchard's paper on "Statistical Bibliography," mentioned earlier, did not appear until 1969.

Another early science policy scholar was the Yugoslav Stevan Dedijer. (Dedijer,1962) Like Tukey he was aware of the work by Derek Price but in those early years there were only vague references to the use of bibliometric data for science policy purposes. Rather, the term “science of science” was used by Price , (Price 1975), Maurice Goldsmith), and others to describe the pioneering work of J.D. Bernal and its offshoots. However, the term did not gain favor even though the Society for the Social Study of Science (4S) was formed in 1975. I plan to present a more detailed analysis of Bernal’s work at the forthcoming celebration of his 100th birthday in Ireland in September.

Using citations to the work of Price as one indicator of the growth of this field here is the year-by-year graph of citations to Derek’s work based on using the histogram feature of *HistCite* or *Web of Science (WoS)*.

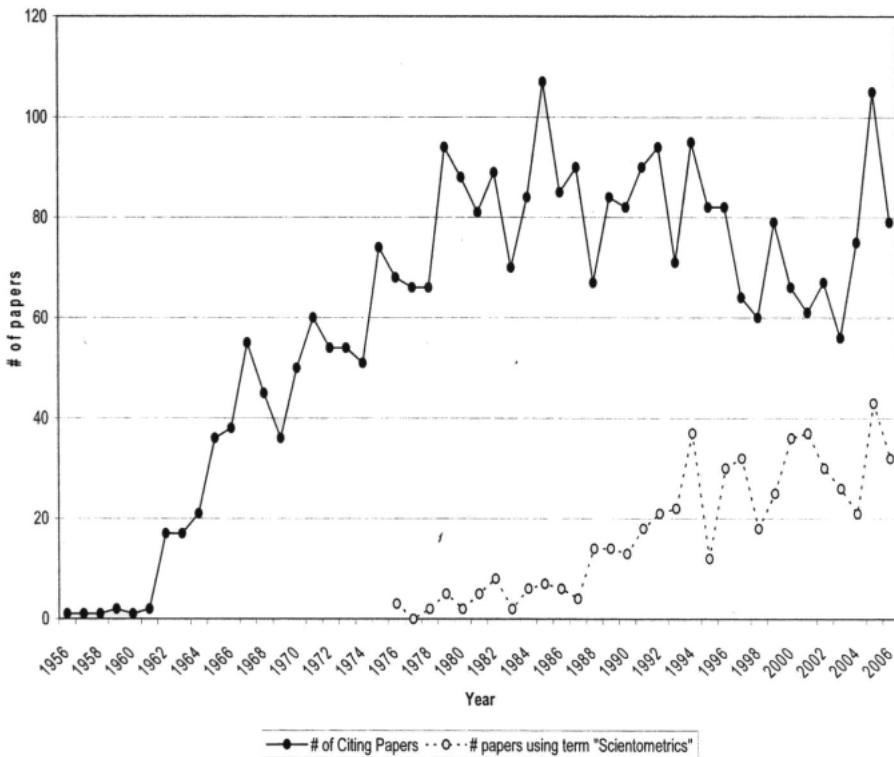


Figure 1. Papers citing Price versus Papers using the term “scientometrics,” from 1956-2006

In contrast to the visible growth in citations to Price’s work, an analysis of papers published in *WOS* containing the term scientometric(s) does not reveal the growth of the topic because the general term is displaced by more specific terminology as the field evolved (Figure 1).

To continue this brief discussion of the work of Derek Price, the following historiograph displays the linkages between the 35 most-cited works of the *HistCite* collection. Each of these papers was cited at least 107 times.

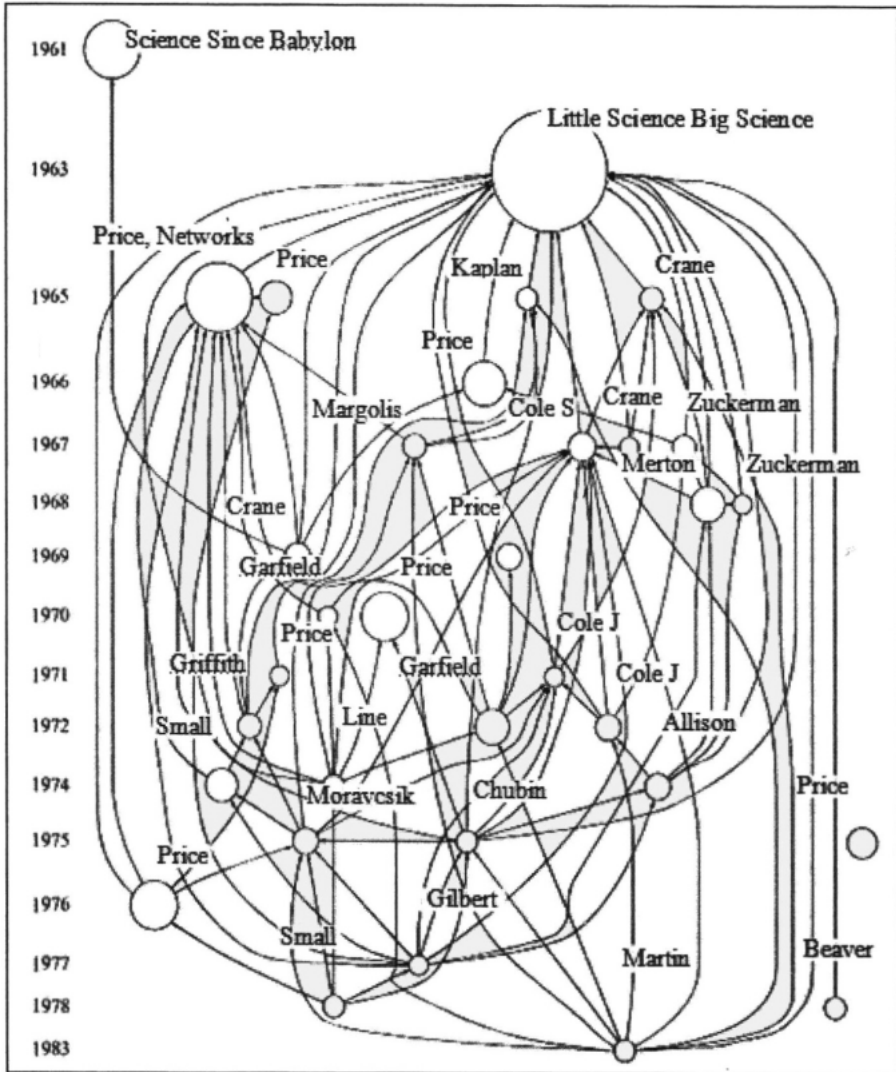


Figure 2. Historiograph of 33 most-cited works in the collection of papers citing Price from 1956-2006

	<b>Author, year, reference</b>	<b>Cites</b>
1	COLE FJ, 1917, SCI PROGR, V11, P578	36
2	LOTKA AJ, 1926, J WASHINGTON ACADEMY, V16, P317	213
3	GROSS PLK, 1927, SCIENCE, V66, P385	39
4	BRADFORD SC, 1934, ENGINEERING-LONDON, V137, P85	69
5	BERNAL JD, 1939, SOCIAL FUNCTION SCI	42
6	BUSH V, 1945, ATLANTIC MONTHLY, V176, P101	65
7	BRADFORD SC, 1948, DOCUMENTATION	84
8	VICKERY BC, 1948, J DOC, V4, P198	24
9	ZIPF GK, 1949, HUMAN BEHAVIOR PRINCIPLE	86
10	FUSSLER HH, 1949, LIBRARY Q, V19, P19	40
11	BARBER B, 1952, SCIENCE SOCIAL ORDER	36
12	LEHMAN HC, 1953, AGE ACHIEVEMENT,	33
13	SIMON HA, 1955, BIOMETRIKA, V42, P425	76
14	GARFIELD E, 1955, SCIENCE, V122, P108	57
15	PRICE DJD, 1956, DISCOVERY, V17, P240	28
16	MERTON RK, 1957, AM SOCIOL REV, V22, P635	76
17	MERTON RK, 1957, SOCIAL THEORY SOCIAL	48
18	SHOCKLEY W, 1957, P IRE, V45, P279	39
19	POPPER K, 1959, LOGIC SCI DISCOVERY	39
20	BURTON RE, 1960, AM DOC, V11, P18	69
21	WESTBROOK JH, 1960, SCIENCE, V132, P1229	27
22	KENDALL MG, 1960, OPERATIONAL RESEARCH, V11, P31	25
23	PRICE DJD, 1961, SCI SINCE BABYLON, P1	337
24	MERTON RK, 1961, P AM PHILOS SOC, V105, P470	35
25	BARBER B, 1961, SCIENCE, V134, P596	30
26	KUHN TS, 1962, STRUCTURE SCI REVOLUTION	199
27	MACHLUP F, 1962, PRODUCTION DISTRIBUT	41
28	ROGERS EM, 1962, DIFFUSION INNOVATION,	27
29	PRICE DJD, 1963, LITTLE SCIENCE BIG SCIENCE, P1	1454
30	KESSLER MM, 1963, AM DOC, V14, P10	61
31	GARFIELD E, 1963, AM DOC, V14, P289	28
32	GARFIELD E, 1963, AM DOC, V14, P195	27
33	GARFIELD E, 1964, USE CITATION DATA WR,	51
34	GARFIELD E, 1964, SCIENCE, V144, P649	37
35	CLARKE BL, 1964, SCIENCE, V143, P822	31
36	PRICE DJD, 1964, SCIENCE, V144, P655	30
37	PRICE DJD, 1965, SCIENCE, V149, P510	499
38	HAGSTROM WO, 1965, SCIENTIFIC COMMUNITY	214
39	PRICE DJD, 1965, TECHNOL CULT, V6, P553	122
40	CRANE D, 1965, AM SOCIOL REV, V30, P699	63
41	KAPLAN N, 1965, AM DOC, V16, P179	50
42	PRICE DJD, 1965, NATURE, V206, P233	33
43	PRICE DJD, 1966, AM PSYCHOL, V21, P1011	213
44	BAYER AE, 1966, SOCIOL EDUC, V39, P381	53
45	CARTTER AM, 1966, ASSESSMENT QUALITY G,	42
46	STORER NW, 1966, SOCIAL SYSTEM SCI,	39
47	SCHMOOKLER J, 1966, INVENTION EC GROWTH,	33
48	BENDAVID J, 1966, AM SOCIOL REV, V31, P451	29
49	STORER NW, 1966, SOCIAL SYSTEM SCIENC,	26
50	MAY KO, 1966, SCIENCE, V154, P1672	24
51	COLE S, 1967, AM SOCIOL REV, V32, P377	91
52	MARGOLIS J, 1967, SCIENCE, V155, P1213	62
53	ZUCKERMAN H, 1967, AM SOCIOL REV, V32, P391	61
54	CRANE D, 1967, AM SOCIOL, V2, P195	44
55	LEIMKUHLER FF, 1967, J DOC, V23, P197	40
56	PRICE DJD, 1967, SCI TECHNOL, V70, P84	33
57	MERTON RK, 1968, SCIENCE, V159, P56	128
58	ZIMAN J, 1968, PUBLIC KNOWLEDGE SOC	68
59	ZUCKERMAN H, 1968, AM J SOCIOL, V74, P276	47
60	BROOKES BC, 1968, J DOC, V24, P247	40
61	MULLINS NC, 1968, AM SOCIOL REV, V33, P786	38
62	MERTON RK, 1968, SOCIAL THEORY SOCIAL	37
63	COLE S, 1968, AM SOCIOL REV, V33, P397	32
64	WATSON JD, 1968, DOUBLE HELIX,	24
65	CRANE D, 1969, AM SOCIOL REV, V34, P335	73
66	PRICE DJD, 1969, P ISRAEL ACAD SCI HU, V4, P98	69
67	PRITCHARD A, 1969, J DOC, V25, P348	47
68	FAIRTHORNE RA, 1969, J DOC, V25, P319	46
69	BROOKES BC, 1969, NATURE, V224, P953	40
70	MACRAE D, 1969, AM SOCIOL REV, V34, P631	34
71	PRICE DJD, 1969, FACTORS TRANSFER TEC, V1, P91	30

Figure 3. Time Line for the History of Scientometrics

The chronological listing of the 200 most-cited works, based on over 102,000 cited references in the collection of 3083 citing papers provides a fairly accurate historical timeline of the field.

Starting with F. J. Cole in 1917, AJ Lotka in 1926, Gross & Gross in 1927, Samuel Bradford in 1934, and then Bernal in 1939. Vannevar Bush's classic, "As we may think" appeared in 1945 at the end of World War II (Bush, 1945). A decade later, we find the work of Herb Simon in 1955, and in the same year, the paper by yours truly. Then in 1956 Derek's first paper on "the exponential growth in science," appears in 1956 (Price, 1956). I won't continue to recite all the names that are recalled in this exercise but I believe this list of works cited 30 or more times in the Price *HistCite* collection demonstrates the simple notion that bibliographic history is recapitulated rather well by the collective bibliographic memory of the scholars who have contributed to the literature, both at the macro and micro level of analysis.

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