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ANALYSIS OF DISTRIBUTION OF THE AGE OF CITATIONS IN THEORETICAL POPULATION GENETICS

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Analyses the age of references cited in source papers of the theoretical population genetics speciality at different phases of its development. Discusses the characteristics of specialities in terms of obsolescence measures such as half-life and immediacy index. Explores the applicability of different theoretical probability functions in the age densities of references cited. Concludes that age of references cited is best modelled according to lognormal distribution.

Introduction

Scientific and technological research papers are derivative and mostly unoriginal because they lean heavily on previous research. The evidence for this statement can be seen in the list of citations that are appended with every new research paper published in a research field.[1] The practice of citing references by authors has been around since long time.[2]

The role of citations has been extensively studied by many scholars over the years.[3] According to *Price*[4, 5] the growth of science is cumulative in nature, in which each research paper is build on the foundation of a previous paper. He points out that patterns of references/citations in research papers indicate the nature of the research front in a research speciality. *Merton*[6] also, through his early work confirmed the theory of cumulative nature of science. He suggests that it is the recognition through citations received which is one of the principal rewards in science. He describes the distinctive and seemingly paradoxical circumstances that in science the more freely scientist gives his intellectual property away, the more surely it is. Apart from its cumulative nature, reference/citation has been viewed as a distinct entity in social system of science.[7] *Kaplan* has proposed that citation should be viewed as a social control mechanism with publications being viewed as property. He states that citation is

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an important institutional device for copying with problem of individual property rights with respect to recognition and claims of priority. While *Kaplan* brought the concept of individual property rights, *Ravetz*[8] introduced the idea of intellectual property rights based on the interpretation that the publication and citation process combine reward and recognition. *Gilbert*[9] has proposed an alternative theory of citing which considers scientific papers as "tools of persuasion". One can say now on the basis of above discussion that the references/citations have been used for various purposes in the past, such as scholarly bricklaying, property right protection, priority claims, and persuasive tool.

Citation practices vary from subject to subject[10] and also depend on the nature of work under consideration. For example, theoretical papers have different citing characteristics than from the papers concerned with experimental work.[11] The citations found in research papers have also been classified by scholars in different ways.[11, 12]

Despite the various reasons why scientists in their own research papers cite other scientists' papers, and various classifications of the different type of citations, one factor in citation practices appears to be universal: references to the past literature are distributed randomly irrespective of the time of publications, a majority will always relate to fairly recent papers. Many reasons have been put forward to explain this phenomenon of obsolescence (ageing): (i) as a result of the growth of science, there is more recent literature available to scientists for citing compared to older literature; (ii) the subject field only recently may have become of interest to practising scientists; (iii) older papers contributed by scientists may contain valid information and ideas which tend to get either incorporated in later works or superseded by later work by scientists. Ageing also depends on the several different ways in which scientists may utilise the literature. The growth in the number of scientists who generate and use information, and their different use patterns of literature belong to this category. The social and political factors and the language of presentation also exert considerable influence on this phenomenon, e. g. *Brunk* and *Jason* found that the two world wars had consideable effect on ageing phenomenon.[13]

Citation studies of obsolescence may be conducted from two different perspectives. Synchronous obsolescence examines references made in a select set of sources at one point of time and reports the distribution of these references to works of varying publication dates and/or age classes. Diachronous obsolescence examine the citations received by a document, a journal, or a collection of papers representing a subject field from the beginning to the end of a particular time period, say 10 to 15 years.

This paper aims at studying the process of citing previous papers by scientists in a scientific speciality at different point of time in its development cycle. The "age" of references cited in a set of core research journals from a speciality is examined, which can be defined as the difference between the year of publication of the citing paper and the year of publication of source reference. The stochastic variable age was modelled with different probability density functions and the most appropriate probability density function best fitting the data over the period of time is examined.

Database and methodology

A synchronous analysis of data has been undertaken in the field of theoretical population genetics. The most comprehensive source of information in this field is *Bibliography of Theoretical Population Genetics,* compiled by *Felsenstein* (1981)[15] covering the literature in this speciality since its inception till the 1980. Based on the analysis of this bibliography, a set of core journals based on their article output, has been identified and selected for study. In order to assess the age of the references for longer duration, we have selected the years 1929, 1939, 1949, 1959, 1969 and 1979, respectively, representing different phases of development of theoretical population genetics speciality. For each year, a minimum number of source articles, depending on the academic year total output in the bibliography, were selected for detailed analysis from core journals. The actual number of source articles selected and the number of citations made in these source articles are shown in Table 1. A cumulated list of references appended to the source papers in a given set of core journals of a particular year has been prepared, noting in each case the date of publication of the references. Since references are usually dated by year, it is assumed to take one year as the unit of time in this study. A reference that is assigned an age of one year, e.g. may have been published in 1928, earlier year to source year publication which was 1929. Using this method, we can combine analysis of all source papers published in a particular year, and the number of references cited by them are sorted out and then arranged in a descending order with respect to years. This is one set of data obtained for one particular year. Similarly, source papers for the academic years 1929, 1939, 1949, 1959, 1969, and 1979, respectively, are analysed for all the citations appended in them, and thus six data sets are generated. Now using these six data sets, we can plot a graph of the number of references cited for each year against the year of source publications (counted backwards from the base year chosen for study). We refer this curve that results from this operation as the "citation decay curve".

Table 1
No. of source articles and their citations in different periods

Year	No. of source articles	No. of citations
1929	9	78
1939	18	201
1949	26	328
1959	39	437
1969	85	1082
1979	146	3200

Analysis and results

Based on the analysis of source papers for the years 1929, 1939, 1949, 1959, 1969, and 1979, respectively, six citation decay curves are obtained. When these citation decay curves are analysed and compared, it is observed that: (i) there are far more references to recent literature than to older literature; (ii) the citation decay curve consists of two parts, in the first part, there is an increase in the number of references cited up to 2 to 3 years, followed by gradual decline towards the older publications in the number of references cited, as given in Fig. 1.

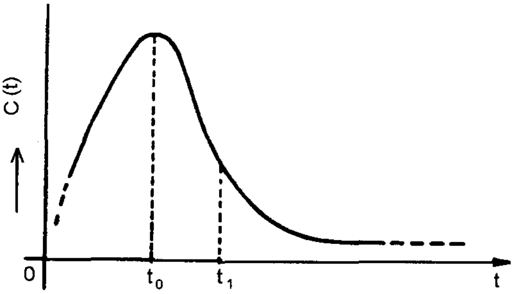

Fig. 1. Schematic form of the citation age distribution *C(t)*

In a fast growing speciality the references cited concern mainly to recent publications, in slow growing specialities the proportion of references cited to older publications is significantly higher. The rate of obsolescence of references is clearly related to the "degree of paradigmaticity of an speciality". A high rate of obsolescence on one hand suggests an orderly step by step regression in a well-defined problem area, where all participants know what the general problems are as well as what the sub-problems look like; so that whenever the answer to one set of sub-problem is found, the whole community easily and quickly moves on to next generation of sub-problems. The slow rate of obsolescence on the other hand indicates that, while the literature accumulates, no substantial progress is made. There is no well-ordered sequence for tackling the sub-problems so that participants work crosscross over each other's contributions.[16]

Both parts of the citation decay curve can be represented by some kind of mathematical function which may be identical or different. If we assume for the time being that the two parts of citation decay curve are exponential, then, for any function varying exponentially with time, a period called half-life can be defined. The classical example of the use of this term was found in the field of radioactive decay, where the half-life represents the time required for half of the original quantity of radioactive material to decay. The significance of half-life applied to citation decay must naturally be different, since scientific literature does not disappear, it is simply not cited. On this analogy, we can say that the citation decay half-life is the period of time during which a half of the currently cited literature was published. Defined in this way, we can allow for changes in the literature being cited; e.g. the citation decay rate may, itself, vary with time (unlike the decay rate of a radioactive material which is constant).

Citation decay curves obtained from different research studies conducted in the past are observed to be varying from one speciality to another speciality, and also in terms of time. Some indicators of the range of half-life of different specialities as calculated in different studies are presented in Table 2.

Table 2
Half-life of different specialities

Subject	Half-life	Subject	Half-life
Physics	4.6	Botany	10.0
Physiology	7.2	Mathematics	10.5
Chemistry	8.1	Geology	11.8

In any typical citation decay curve, the two portions observed have different physical significance. One can, therefore, define two different half-life, depending upon the portion of the curve under consideration. It is generally observed that: (i) references/citations to the recent literature are considered for a first decade, and first half-life is calculated from this period; (ii) references to the old literature are considered for all those citations which are more than 20 years old, and the second half-life is calculated from this period. The half-life quoted in Table 2, refers mainly to the first portion of the curve (first decade) for each speciality.

Table 3
Half life of theoretical population genetics literature

Period	First half-life	Second half-life
1929	6.714	7.50
1939	6.375	7.33
1949	5.580	10.30
1959	4.888	6.42
1969	4.446	14.00
1979	4.302	9.80

Looking at the changes in the first half-life of theoretical population genetics speciality, it is seen to have substantially decreased from 6.714 in 1929 to 4.302 in 1979, and the trend is consistent over the years. It also indicates that the research front of theoretical population genetics speciality is fast changing over time. The mean average of the first half-life over the entire period is 5.384 years. On the other hand, the second half-life over the years does not show any systematic increase or decrease. The mean average of the second half-life over the entire period is 9.22 years. The first half-life is most significant because it is calculated from the citations made in the first decade, which constitute roughly 80 to 90% of the total citations made, as can be seen in age analysis of the data presented in Table 4.

Table 4
Age of references cited/No. of references

Year	Age of references cited/No.of references					Total
	1–10 Years	11–20 Years	21–30 Years	31–40 Years	41– Years	
	No. of references					
1929	48	22	8	0	0	78
1939	120	46	15	9	11	201
1949	120	134	25	17	32	327
1959	276	86	42	12	21	431
1969	741	198	49	41	53	1082
1979	2201	527	240	96	136	3200

Comparing the literature growth and the citation decay curve, it is observed that the second part of the citation decay curve which account for 70 per cent of all cited papers, bears some resemblence to the normal growth curve. It means that the 70 per cent citations represent a random distribution of citations of all papers that have been published regardless of the date. The first part of the curve, comprising of 30 per cent of the highly cited references to recent literature, corresponds to a more rapid decay, and the distribution of citations of the recent papers is defined by the shape curve, half of the 30 per cent being papers between 1 and 6 years old. This must be interpreted, as excessive citation of the recent literature. *Price*[16] has called this overcitation the "immediacy effect". The effect can be seen more distinctingly if instead' of plotting citation decay curve in exponential form, it is plotted logarithmically.[17]

Price has made a distinction between, on the one hand, what he calls *archival* body of scientific literature, and, on the other hand, in the research front literature. The archival literature is the most substantial part and is compared to the body of science, while the research front literature, which might be relatively small in size, is referred to as the growing skin. According to this image, science not only grows like a tree, in the sense of branching off in twigs but it also resembles a tree in growing only on the outside being supported by a lifeless stable structure from within. The archival body of literature is rarely used in the construction of new speciality; the research front literature is, as far as can be determined from the references cited, is heavily used in that respect.

Price[16] further elaborates that the "the thinner the skin of science the more orderly and crystalline the growth and the more rapid the process", refers to the width of that segment of literature heavily referred to the new papers continuously added in the area. In fast growing speciality, this area is very thin. Papers after entry into a speciality, very soon become obsolete in the sense that their content is readily assimilated and integrated into the body of knowledge so that specific reference to them is superfluous. They become part of the archival body which serves more the purpose of history itself. In slow growing specialities, the research front literature is a much wider segment of the literature, and it might be difficult to distinguish between archival and research front literature. *Menard*[19] points out that slower growing specialities can expand by periodically dragging up unsolved problems or by questionning semi-accepted solutions, so that time and again the old literature is brought back as potentially relevant.

The immediacy factor can also be expressed quantitatively by, e.g. the difference in the slope of two portions of the citation decay curve plotted logarithemically. This can be represented by some kind of index,[19] and in detailed studies it may necessarily to do so; but a simpler version of immediacy – the proportion of references in the considered set that have been published in the previous five years – seems adequate for this purpose.[17] *Price* has worked out values of this simple index for large variety of journals and subjects, and has found that, if it is averaged over all fields, it comes to somewhat over 50%. In terms of different specialities, Price's Index of fast growing specialities might be as high as 80, and even more dormant specialities do not exceed 20. The recency of the references cited seems to reflect on aspects of the metabolism of growth of different specialities.

Looking at the percentage of citations in the first five block years of theoretical population genetics speciality, as given in Table 5, it is seen that the immediacy index has systematically increased from 39.74% in 1929 to 47.75% in 1979, reflecting on the speed with which the current literature is getting obsolete and the way the changes in the structure of research front are taking place.

Table 5
Immediacy index of theoretical population genetics speciality

Year	Percentage of citation in first five years
1929	39.74
1939	37.81
1949	38.41
1959	42.11
1969	47.60
1979	47.75

Figure 8 presents data on the quartiles of the age of references cited (considering all the citations) in the source publications for the six data sets being studied. It is observed to be quite stable with time with little fluctuations. The peak age was highest during the years 1939 to 1949 in all the three quartiles. This observation is quite in agreement with the results obtained by *Price* and according to him these fluctuations are as a result of the World War II; the papers cited during this period are markedly older.

The shapes of the decay curves, as observed in different research studies are distorted appreciably, in general. The most obvious deviations usually occur in the tail of the citation decay curve, corresponding to the older literature, since the number of references here are small, and the probable scatter large. The tail and the central regions of the citation decay curves are also noticeably affected by two World Wars.

Another deviation from the standard curve that can nearly always be observed, occur in the most recent references, the numbers of which normally fall below the expected level. *Burton* and *Kebler* (1960)[20] suspected that the number of these references might be less for a period as long as three years, before the appearance of a citation article. More generally, a comparison of references counts from a variety of research studies suggests that the period of deficiency may last anything from one to three years. The terminal distortion can be ascribed to a variety of causes. One obvious factor is the time lag between the publication of the paper and the publication of the first reference to it. But this lag is, itself, built up from several components – the time required for assimilation of new research results; the time taken up in further incorporating these results; the time passes before the consequent paper appears in print.

Applicability of theoretical probability functions

Assume T as the age of reference, a discrete variable measured in years. In this paper, however, we have considered T as a continuous variable, both because it may be considered as such, and because the statistical analysis is simpler. We have analysed the statistical distribution of T of source papers from core journals in theoretical population genetics for the years 1929, 1939, 1949, 1959, 1969 and 1979, respectively. Now, different theoretical probability functions were tried for their goodness-in-fit in the age densities. It was found that these types of densities are best modelled by lognormal probability density function defined as:

$$P(r) = \frac{1}{r\sigma\sqrt{2\pi}} e^{\left[-\log r - \mu^2/2\sigma^2\right]} \qquad 0 < r < \infty$$

where

$$\text{Mean} = e^{(\mu+\sigma^2/2)}$$
$$\text{Variance} = \sigma^2 = e^{(2\mu+\sigma^2)} e\ \sigma^2 - 1$$

ln is the logarithm to the natural base e,
μ is the average value, and
σ is the standard deviation of ln (T).

The histograms of the densities of age of references cited of the source papers in years 1929, 1939, 1949, 1959, 1969 and 1979, respectively, in theoretical population genetics are shown in Figs 2 to 7. When the histograms of the age of references cited are compared with Price's results, they are found to be different, as explained below. *Price,*[4] while analysing scientific literature identified two well-defined regions in the plotting of density with age: (i) a region of papers more frequently cited (30%), and (ii) a region of less frequently cited papers (70%).

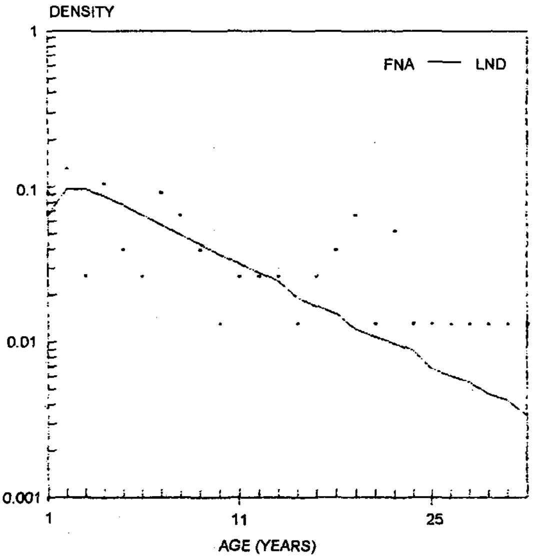

Fig. 2. Histogram of probability density of the age of the references cited in TPG in 1929

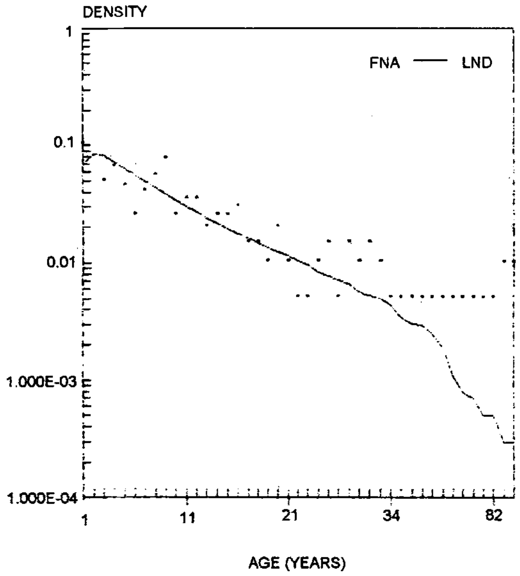

Fig. 3. Histogram of the probability density of the age of the references cited in TPG in 1939

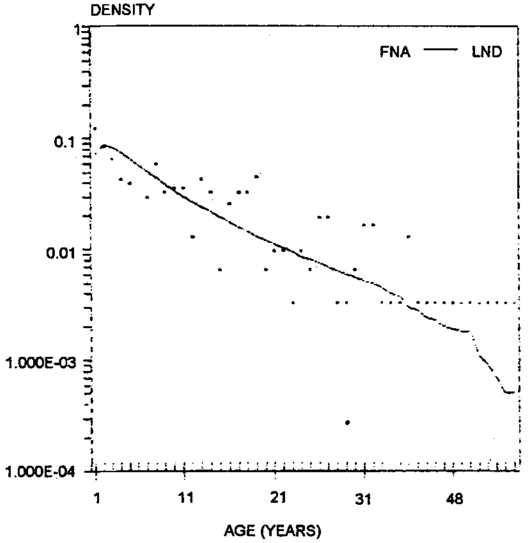

Fig. 4. Histogram of the probability density of the age of the references cited in TPG in 1949

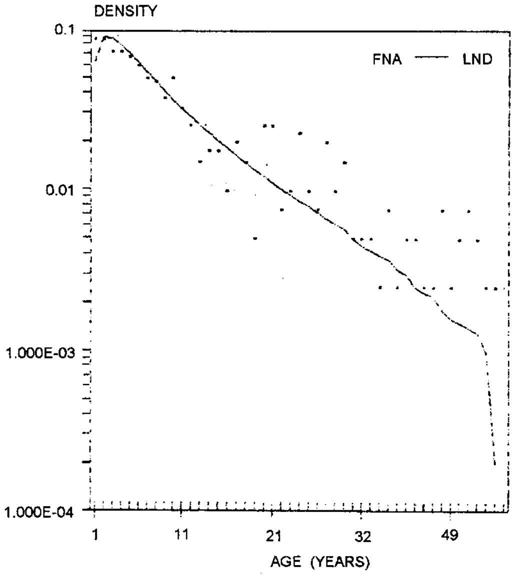

Fig. 5. Histogram of the probability density of the age of the references cited in TPG in 1959

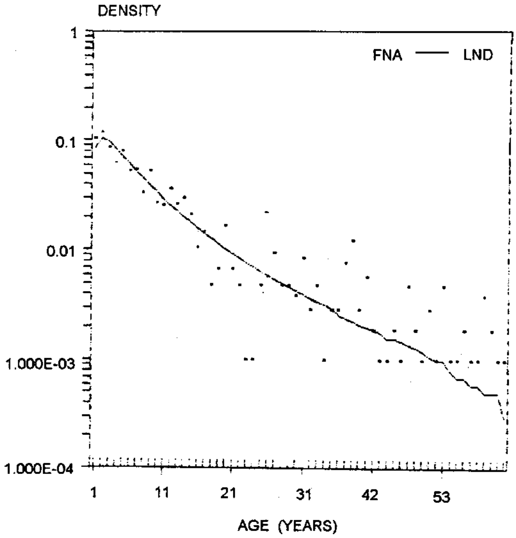

Fig. 6. Histogram of the probability density of the age of the references cited in TPG in 1969

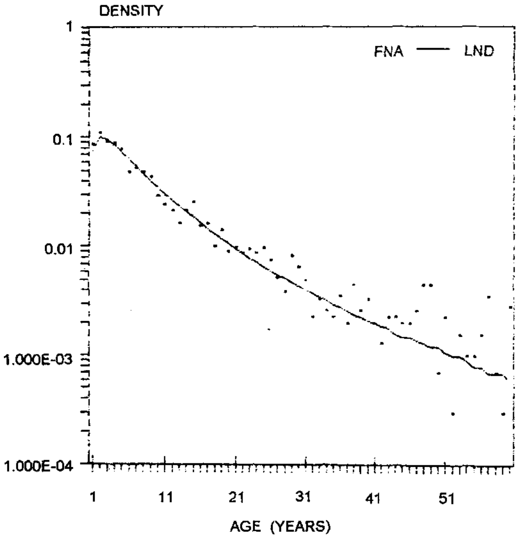

Fig. 7. Histogram of the probability density of the age of the references cited in TPG literature in 1979

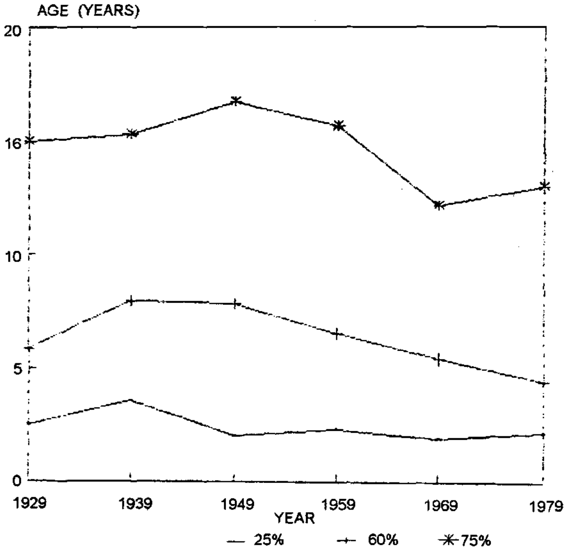

Fig. 8. Quartiles of the age of the references cited in TPG from 1929 to 1979 in block of ten years each

If we look at the histogram of the observed distributions for different years in a linear-log grid, we notice that, excluding the values where the statistical noise is evident (values less than 10^{-2}), the density of the sample does not decay exponentially, which *Price* found, but with a much slower rate.

The lognormal distribution is applied in the six data sets of citations appearing in source papers for various years. The numerical values of the mean, medium, and standard deviation of the lognormal distribution, as applied to these six empirical or observed distributions are given in Table 6.

Table 6
Values of statistics obtained from the application of lognormal distribution to the six databsets

	1929	1939	1949	1959	1969	1979
Mean	1.899	2.059	2.024	2.003	1.841	1.876
Medium	5.86	8.00	7.89	6.55	5.48	4.48
Standard Deviation	0.997 6	1.1376	1.1326	1.0594	1.0754	1.0475

The observed distribution and the estimated values obtained by application of lognormal distribution to the citations appearing in source journals for six datasets are given in *Appendix 1.* A K-S statistical test was applied to test the applicability of lognormal distribution in each of the six observed data distributions and the results obtained are given in Table 7.

Table 7
Value of D_{max} obtained by application of lognormal distribution in six observed distributions for years from 1929 to 1979

Distribution year	Value of D_{max} obtained	K–S statistics
1929	0.1174	0.1858
1939	0.1028	0.1173
1949	0.0716	0.0924
1959	0.0556	0.0807
1969	0.0321	0.0507
1979	0.0193*	0.0295

The results indicate that lognormal distribution showed positive fits in all the datasets of citations appearing in source articles for the years 1929, 1939, 1949, 1959, 1969 and 1979. A graphical presentation of the observed and estimated distribution for each year is presented in Figs 2 to 7. From this analysis, we conclude that the more natural estimate of the age of paper is not the number of years (T) elapsed since its application, but the logarithm of this number [$\ln(T)$]. These results are quite in agreement with the results obtained by other scholars.[21, 22]

Conclusions

The analyses of age of references in source papers of theoretical population genetics speciality indicate the patterns in the references cited. It throws light on the extent of obsolescence and the rate at which the speciality literature is getting obsolete over time. Both these aspects throw some light on the degree of paradigmaticity of the theoretical population genetics speciality. The characteristics of the theoretical population genetics speciality in terms of obsolescence measures such as half-life and Price Index are discussed. Both these measures are found to be increasing with time, throwing light on how the research front and the structure of the speciality is changing with time. The quartiles of the age of references (of total references) calculated and plotted indicate that age of references cited is observed to be quite stable with time, except for period 1939 and 1949, indicating the effect of World War II. The analyses also explore the applicability of different probability density functions that best describe the age of references cited in source papers. The study concludes that the age of references cited in source papers of theoretical population genetics, irrespective of the period studied, is found to be best modelled according to a simple lognormal probability density function. It suggests that the more natural estimate of the age of reference is not the number of years elapsed since it was published, but rather the logarithm of this number. In this particular speciality, the probability density function is found to be quite stable over the years studied in six datasets from 1929 to 1979.

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Appendix 1

The observed distribution and the estimated values from the lognormal distribution in the following source year data

1929

t	c(t) observed	FNA	LND	D_{max}
1	7	0.0909	0.0653	–0.0256
2	10	0.1299	0.0963	–0.0592
3	2	0.0260	0.0966	0.0114
4	8	0.1039	0.0876	–0.0049
5	3	0.0390	0.0767	0.0328
6	2	0.0260	0.0663	0.0731
7	7	0.0909	0.0571	0.0392
8	5	0.0649	0.0492	0.0235
9	3	0.0390	0.0425	0.0270
10	1	0.0130	0.0368	0.0508
11	2	0.0260	0.0321	0.0569
12	2	0.0260	0.0280	0.0589
13	2	0.0260	0.0246	0.0575
15	1	0.0130	0.0192	0.0637
16	2	0.0260	0.0170	0.0547
17	3	0.0390	0.0152	0.0309
19	5	0.0649	0.0122	–0.0218
20	1	0.0130	0.0109	–0.0239
21	4	0.0519	0.0098	–0.0660
22	1	0.0130	0.0089	–0.0701
25	1	0.0130	0.0067	–0.0764
26	1	0.0130	0.0061	–0.0833
27	1	0.0130	0.0056	–0.0908
29	1	0.0130	0.0047	–0.0991
30	1	0.0130	0.0043	–0.1078
33	1	0.0130	0.0034	–0.1174

1939

t	c(t) observed	FNA	LND	D_{max}
1	20	0.1036	0.0682	–0.0354
2	16	0.0829	0.0853	–0.0330
3	10	0.0518	0.0819	–0.0029
4	13	0.0674	0.0736	0.0033
5	9	0.0466	0.0649	0.0215
6	5	0.0259	0.0569	0.0525
7	8	0.0415	0.0498	0.0608
8	11	0.0570	0.0438	0.0477
9	15	0.0777	0.0387	0.0086
10	5	0.0259	0.0343	0.0170
11	7	0.0363	0.0305	0.0112
12	7	0.0363	0.0272	0.0021
13	4	0.0207	0.0244	0.0058
14	5	0.0259	0.0220	0.0019
15	5	0.0259	0.0199	–0.0041
16	6	0.0311	0.0180	–0.0172
17	3	0.0155	0.0164	–0.0163
18	3	0.0155	0.0149	–0.0169
19	2	0.0104	0.0136	–0.0137
20	4	0.0207	0.0125	–0.0219
21	2	0.0104	0.0115	–0.0209
22	1	0.0052	0.0106	–0.0155
23	1	0.0052	0.0097	–0.0110
25	2	0.0104	0.0083	–0.0130
26	3	0.0155	0.0077	–0.0208
27	1	0.0052	0.0072	–0.0188
28	3	0.0155	0.0067	–0.0276
30	2	0.0104	0.0058	–0.0322
31	3	0.0155	0.0054	–0.0422
32	2	0.0104	0.0051	–0.0475
34	1	0.0052	0.0045	–0.0482
38	1	0.0052	0.0035	–0.0499
40	1	0.0052	0.0031	–0.0520
41	1	0.0052	0.0030	–0.0542
44	1	0.0052	0.0025	–0.0569
50	1	0.0052	0.0019	–0.0602
62	1	0.0052	0.0011	–0.0643
69	1	0.0052	0.0008	–0.0687
74	1	0.0052	0.0007	–0.0733
80	1	0.0052	0.0005	–0.0779
82	1	0.0052	0.0005	–0.0826
100	2	0.0104	0.0003	–0.0927
101	2	0.0104	0.0003	–0.1028

1949

t	c(t) observed	FNA	LND	D_{max}
1	38	0.1222	0.0714	–0.0508
2	26	0.0836	0.0883	–0.0461
3	20	0.0643	0.0841	–0.0263
4	13	0.0418	0.0751	0.0070
5	12	0.0386	0.0659	0.0343
6	13	0.0418	0.0575	0.0500
7	9	0.0289	0.0502	0.0713
8	18	0.0579	0.0440	0.0573
9	10	0.0322	0.0387	0.0638
10	11	0.0354	0.0342	0.0626
11	11	0.0354	0.0303	0.0575
12	4	0.0129	0.0270	0.0716
13	13	0.0418	0.0242	0.0540
14	10	0.0322	0.0217	0.0435
15	2	0.0064	0.0196	0.0566
16	8	0.0257	0.0177	0.0486
17	10	0.0322	0.0160	0.0325
18	10	0.0322	0.0146	0.0149
19	14	0.0450	0.0133	–0.0168
20	2	0.0064	0.0122	–0.0110
21	3	0.0096	0.0112	–0.0095
22	3	0.0096	0.0103	–0.0088
23	1	0.0032	0.0095	–0.0025
24	3	0.0096	0.0087	–0.0034
25	2	0.0064	0.0081	–0.0017
26	6	0.0193	0.0075	–0.0136
27	6	0.0193	0.0069	–0.0259
28	1	0.0032	0.0065	–0.0227
29	1	0.0032	0.0060	–0.0199
30	2	0.0064	0.0056	–0.0206
31	5	0.0161	0.0052	–0.0315
32	5	0.0161	0.0049	–0.0427
33	1	0.0032	0.0046	–0.0413
35	1	0.0032	0.0040	–0.0405
36	1	0.0032	0.0038	–0.0399
40	4	0.0125	0.0030	–0.0498
41	1	0.0032	0.0028	–0.0502
44	1	0.0032	0.0024	–0.0510
45	1	0.0032	0.0023	–0.0519
47	1	0.0032	0.0020	–0.0531
48	1	0.0032	0.0019	–0.0544
45	1	0.0032	0.0018	–0.0557
50	1	0.0032	0.0018	–0.0572
60	1	0.0032	0.0011	–0.0593
65	1	0.0032	0.0009	–0.0616
72	1	0.0032	0.0007	–0.0641
82	1	0.0032	0.0005	–0.0668
83	1	0.0032	0.0005	–0.0696

1959

t	c(t) observed	FNA	LND	D_{max}
1	35	0.0858	0.0631	–0.0227
2	35	0.0858	0.0877	–0.0208
3	29	0.0711	0.0872	–0.0047
4	29	0.0711	0.0795	0.0036
5	27	0.0662	0.0703	0.0077
6	24	0.0588	0.0615	0.0104
7	20	0.0490	0.0537	0.0151
8	19	0.0466	0.0469	0.0155
9	15	0.0368	0.0411	0.0198
10	20	0.0490	0.0362	0.0070
11	13	0.0319	0.0319	0.0070
12	10	0.0245	0.0283	0.0108
13	6	0.0147	0.0252	0.0212
14	7	0.0172	0.0225	0.0265
15	7	0.0172	0.0201	0.0294
16	4	0.0098	0.0181	0.0377
17	8	0.0196	0.0163	0.0344
18	6	0.0147	0.0147	0.0344
19	2	0.0049	0.0133	0.0428
20	10	0.0245	0.0121	0.0305
21	10	0.0245	0.0111	0.0170
22	3	0.0074	0.0101	0.0197
23	4	0.0098	0.0092	0.0192
24	9	0.0221	0.0085	0.0055
25	4	0.0098	0.0078	0.0035
26	3	0.0074	0.0072	0.0033
27	8	0.0196	0.0066	–0.0097
28	4	0.0098	0.0061	–0.0133
29	6	0.0147	0.0057	–0.0224
31	2	0.0049	0.0049	–0.0224
32	2	0.0049	0.0045	–0.0228
33	2	0.0049	0.0042	–0.0234
34	1	0.0025	0.0039	–0.0220
35	3	0.0074	0.0037	–0.0257
37	1	0.0025	0.0032	–0.0250
38	2	0.0049	0.0030	–0.0269
41	2	0.0049	0.0025	–0.0293
42	1	0.0025	0.0023	–0.0295
43	1	0.0025	0.0022	–0.0298
47	3	0.0074	0.0018	–0.0354
49	1	0.0025	0.0016	–0.0363
50	2	0.0049	0.0015	–0.0398
51	3	0.0074	0.0014	–0.0457
52	2	0.0049	0.0013	–0.0493
58	1	0.0025	0.0010	–0.0508
100	1	0.0025	0.0002	–0.0531
196	1	0.0025	0.0000	–0.0556

1969

t	c(t) observed	FNA	LND	D_{max}
1	107	0.1036	0.0857	–0.0179
2	123	0.1191	0.1049	–0.0321
3	89	0.0862	0.0974	–0.0209
4	64	0.0620	0.0848	0.0018
5	83	0.0803	0.0725	–0.0060
6	54	0.0523	0.0617	0.0035
7	56	0.0542	0.0527	0.0020
8	34	0.0329	0.0452	0.0143
9	54	0.0523	0.0390	0.0010
10	28	0.0271	0.0338	0.0078
11	26	0.0252	0.0295	0.0121
12	37	0.0358	0.0258	0.0021
13	27	0.0261	0.0227	–0.0012
14	31	0.0300	0.0201	–0.0111
15	22	0.0213	0.0179	–0.0146
16	11	0.0106	0.0159	–0.0092
17	15	0.0145	0.0143	–0.0095
18	5	0.0048	0.0128	–0.0015
19	7	0.0068	0.0115	0.0033
20	17	0.0165	0.0104	–0.0028
21	7	0.0068	0.0094	–0.0002
22	5	0.0048	0.0086	0.0036
23	1	0.0010	0.0078	0.0104
24	1	0.0010	0.0071	0.0166
25	5	0.0048	0.0065	0.0183
26	6	0.0058	0.0060	0.0185
27	10	0.0097	0.0055	0.0143
28	5	0.0048	0.0051	0.0146
29	5	0.0048	0.0047	0.0144
30	4	0.0039	0.0043	0.0149
31	9	0.0087	0.0040	0.0102
32	3	0.0029	0.0037	0.0110
33	5	0.0048	0.0034	0.0096
34	1	0.0010	0.0032	0.0118
35	3	0.0029	0.0030	0.0119
37	3	0.0029	0.0026	0.0116
38	8	0.0077	0.0024	0.0063
39	13	0.0126	0.0023	–0.0041
40	3	0.0029	0.0021	–0.0048
41	6	0.0058	0.0020	–0.0086
42	2	0.0019	0.0019	–0.0087
43	1	0.0010	0.0018	–0.0079
44	1	0.0010	0.0016	–0.0073

1969 (Cont.)

t	c(t) observed	FNA	LND	D_{max}
45	2	0.0019	0.0016	–0.0076
46	1	0.0010	0.0015	–0.0072
47	5	0.0048	0.0014	–0.0106
48	2	0.0019	0.0013	–0.0112
49	1	0.0010	0.0012	–0.0110
51	3	0.0029	0.0011	–0.0128
52	1	0.0010	0.0010	–0.0127
53	5	0.0048	0.0010	–0.0165
57	1	0.0010	0.0008	–0.0167
59	1	0.0010	0.0007	–0.0170
60	2	0.0019	0.0007	–0.0182
62	1	0.0010	0.0006	–0.0186
63	1	0.0010	0.0006	–0.0190
65	4	0.0039	0.0005	–0.0224
66	2	0.0019	0.0005	–0.0237
69	1	0.0010	0.0005	–0.0243
80	1	0.0010	0.0003	–0.0250
103	1	0.0010	0.0001	–0.0259
110	1	0.0010	0.0001	–0.0268

1979

t	c(t) observed	FNA	LND	D_{max}
1	263	0.0862	0.0766	–0.0096
2	335	0.1098	0.1006	–0.0188
3	277	0.0908	0.0964	–0.0132
4	269	0.0882	0.0853	–0.0161
5	235	0.0770	0.0737	–0.0193
6	149	0.0488	0.0633	–0.0049
7	157	0.0515	0.0543	–0.0021
8	147	0.0482	0.0467	–0.0036
9	131	0.0429	0.0404	–0.0061
10	89	0.0292	0.0350	–0.0003
11	74	0.0243	0.0306	0.0060
12	64	0.0210	0.0268	0.0118
13	50	0.0164	0.0236	0.0190
14	64	0.0210	0.0209	0.0189
15	77	0.0252	0.0185	0.0122
16	47	0.0154	0.0165	0.0133
17	49	0.0161	0.0148	0.0119
18	31	0.0102	0.0132	0.0150
19	43	0.0141	0.0119	0.0128
20	28	0.0092	0.0108	0.0143
21	30	0.0098	0.0097	0.0143
22	27	0.0088	0.0088	0.0143
23	29	0.0095	0.0080	0.0128
24	27	0.0088	0.0073	0.0114
25	30	0.0098	0.0067	0.0083
26	23	0.0075	0.0061	0.0069
27	16	0.0052	0.0056	0.0073
28	12	0.0039	0.0052	0.0086
29	26	0.0085	0.0048	0.0049
30	20	0.0066	0.0044	0.0027
31	15	0.0049	0.0041	0.0018
32	7	0.0023	0.0038	0.0033
33	10	0.0033	0.0035	0.0035
34	8	0.0026	0.0032	0.0041
35	7	0.0023	0.0030	0.0048
36	11	0.0036	0.0028	0.0040
37	6	0.0020	0.0026	0.0047
38	14	0.0046	0.0024	0.0025
39	8	0.0026	0.0023	0.0022
40	10	0.0033	0.0021	0.0010
41	6	0.0020	0.0020	0.0010
42	4	0.0013	0.0019	0.0016
43	7	0.0023	0.0018	0.0010

1979 (Cont.)

t	c(t) observed	FNA	LND	D_{max}
44	7	0.0023	0.0016	0.0004
45	6	0.0020	0.0015	–0.0001
46	6	0.0020	0.0015	–0.0006
47	8	0.0026	0.0014	–0.0019
48	14	0.0046	0.0013	–0.0052
49	14	0.0046	0.0012	–0.0085
50	2	0.0007	0.0012	–0.0081
51	7	0.0023	0.0011	–0.0093
52	1	0.0003	0.0010	–0.0086
53	5	0.0016	0.0010	–0.0092
55	3	0.0010	0.0009	–0.0093
56	3	0.0010	0.0008	–0.0095
57	5	0.0016	0.0008	–0.0103
58	11	0.0036	0.0007	–0.0132
59	2	0.0007	0.0007	–0.0132
60	1	0.0003	0.0007	–0.0128
61	9	0.0029	0.0006	–0.0150
62	1	0.0003	0.0006	–0.0147
63	1	0.0003	0.0006	–0.0145
71	1	0.0003	0.0004	–0.0144
72	1	0.0003	0.0004	–0.0143
74	1	0.0003	0.0004	–0.0142
97	1	0.0003	0.0001	–0.0144
100	1	0.0003	0.0001	–0.0146
102	3	0.0010	0.0001	–0.0154
103	1	0.0003	0.0001	–0.0156
112	1	0.0003	0.0001	–0.0158
117	2	0.0007	0.0001	–0.0165
120	1	0.0003	0.0001	–0.0167