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THE LIFE CYCLE OF SCHOLARS AND PAPERS IN ECONOMICS -- THE "CITATION
DEATH TAX"

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ABSTRACT

The information content of academic citations is subject to debate. This paper views premature death as a tragic "natural experiment," outlining a methodology identifying the "citation death tax" -- the impact of death of productive economists on the patterns of their citations. We rely on a sample of 428 papers written by 16 well known economists who died well before retirement, during the period of 1975-97. The news is mixed: for half of the sample, we identify a large and significant "citation death tax" for the average paper written by these scholars. For these authors, the estimated average missing citations per paper attributed to premature death ranges from 40% to 140% (the overall average is about 90%), and the annual costs of lost citations per paper are in the range 3% and 14%. Hence, a paper written ten years before the author's death avoids a citation cost that varies between 30% and 140%. For the other half of the sample, there is no citation death tax; and for two Nobel Prize-caliber scholars in this second group, Black and Tversky, citations took off overtime, reflecting the growing recognitions of their seminal works.

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1. Introduction

One approach for measuring the impact and diffusion of academic research is by studying the quantity and pattern of citations to published research findings. The literature on the diffusion of technological innovations frequently uses patent citation data to study the spread of technological knowledge.¹ However, as emphasized in a large literature on the sociology of science, citations to the publications of researchers by other researchers may be influenced by considerations beyond the strict linkage between new findings and old findings. Citation practices depend on academic culture and traditions, and the incentives to cite may not accord with the notion that citations provide an approximate record of the origin of ideas used. Because scholarship is costly, the rates of citation to specific articles can also depend on the promotion by the authors or more general personal networking by authors.

This paper considers the question of whether citations depend only on the intrinsic contribution of a publication or are influenced by the author's professional presence by estimating the impact of premature death of productive economists on their citations. Death in the midst of an active career may affect citations by eliminating the opportunity of the researcher to raise awareness of their research findings or by eliminating the incentives of others to cite for strategic reasons. If premature death leads to a drop in citations, the citations of papers written by deceased authors will be front loaded relative to other papers of the same vintage, and this effect will be larger the shorter is the time between author's death and the year of the paper's publication. We confirm these predictions for half of the authors in our sample, and find that these effects are large.

There is a significant literature on the use and usefulness of citations to academic journal articles for measuring research quality and researcher productivity. The use of citations in the evaluation of scientific careers and compensation of academic researchers motivates much of the interest in citations patterns and the motives to cite. This is the subject of a large literature in the sociology of science (see Cole and Cole (1973), Merton (1973) and references thereto) that examines citation behaviour and incentives. Within economics, citations are used frequently to rank journals, departments and economists.² While citations serve the purpose of conveying information in academic exposition, the

¹ Examples of this literature include the chapters in Jaffe and Trajtenberg (2002).

² Palacios-Huerta and Volij (2004) consider such rankings and provide references to this literature in part.

rewards to being cited and the role of others in the peer reviewing process affect the incentives to cite. The possibilities of strategic citation behavior and editorial bias have received attention in economics (Posner (2000) and Laband and Piette (1994), respectively). Information costs are also important for understanding citations. Networking increases the familiarity with a researcher's work lowering the information cost to others of citing that work. In the economics profession, networking has been studied in the context of citation circles based on graduate education (Stigler and Friedland (1975), gender differences in citation frequency (Ferber (1988)) and the research gains associated with co-authorship (Sauer (1988) and Laband and Tollison (2000)).

Our paper contributes to this literature by estimating the citation cost of lost networking triggered by premature death of active scholars. Our findings dealing with the large cost of lost networking have several interpretations. Premature death terminates activities that help enhance the prominence of scholar's publications, such as presenting papers, pursuing follow-up research, encouraging related research by others and supervising Ph.D. students. Some of these costs may be mitigated in circumstances where the research was done jointly with active and productive scholars. The loss of some citations may result from the termination of the incentives for strategic citation. A researcher's death can also have the direct effect of reducing research activity on a particular topic. Identifying the precise importance of all these factors requires much more detailed information about various dimensions of networking and is beyond the data available and scope of the present paper.

Section 2 outlines the methodology. In the first stage, we assembled a list of the papers written by well known economists that died before reaching age 65, 1975-1997. Applying well defined criteria, we ended up with a sample of 428 papers written by 16 economists. We constructed the intertemporal path of missing citations of a paper in the sample relative to the hypothetical citations had the author been alive, and calculated for each paper the cumulative missing citations. The ratio of the missing citations relative to the overall citations of each paper provides us with the "citation death tax rate" of each paper. Statistical analysis of the missing citation rate reveals that for half of the authors, the missing citation rate is large and significant. We also find that for these authors, the missing citation ratio of a paper is smaller the longer the time elapsing between the paper's publication date and author's death. Section 3 discusses robustness, and possible extensions. Section 4 discusses the incentives to cite and relates these to the empirical findings.

2. The methodology

We assembled the list of well known economists that died before reaching possible retirement age (65), applying the following criteria:

- Died between 1975-1997, hence we have at least 9 years of citations record past death.
- Average citation/year in the Web of Science exceeds 2.
- The author appears in the deceased list assembled by the *IDEAS-REPEC* project [<http://ideas.repec.org/i/erip.html>], or are reviewed at the *New Palgrave Dictionary of Economics*.

The resultant sample includes 16 economists [see Table 1]. It covers renowned economists that died prematurely -- 2 in their 30s, 3 in their 40s, 8 in their 50s, and 3 at their early 60s (< 65). They are at varying level of prominence -- 5 economists with average citation/year between 2 and 10, 5 economists with average citation/year between 10 and 20, 4 with average citation/year between 20 and 100, and two Nobel prize-caliber scholars, with average citations/year exceeding 100 (Fischer Black and Amos Tversky). Using the Web of Science system, we assembled a panel of the annual citations of 428 papers written by the 16 economists in the sample, in the years 1957-2006.³

The Web of Science provides us with useful information regarding the dynamics of average citations per paper written in a given year. Figure 1a provides this information for papers with at least one citation for selective years [1956, 59, 65, 71, 77, 83, 89, 95, 2001]. The samples are restricted to economics articles written in English. The Figure suggests upward rotation of the citation curves overtime: papers written more recently tend to be cited more during the citation cycle, and paper's citations tend to peak at a later stage of the citation cycle during the last twenty years. These changes may reflect both the advent of the Internet, and the impact of the growth of the size of Economics and thereby the number of papers published each year. Figure 1b controls for this size effect by deflating the citation curves by a size index $I(t)$, defined by of the number of papers published at year t relative to the number published at the base year, 1956. The index is portrayed in Figure 2, showing that the number of published papers more than tripled from 1971. The rapidly expanding size of papers in economics explains some of the patterns in Figure 1a -- the citations curves dealing with papers written in the 1950s

³ Table 1 excludes self citations. The main results of our paper turned out to hold with and without self-citations.

peaked at much later years, or remain upward sloping due to the large increase in papers published in later years.

2.1 Citation death tax, definition and results

We outline a methodology to test the degree to which premature death frontloads citations of deceased author relative to other papers of the same vintage. It is convenient to adopt the following notation:

$x_{t,t+k}$, $k = 0, 1, 2, \dots$, is the average citations at time $t+k$ of papers written in year t . The citation curves of papers written at time t provided in Figure 1a correspond to $x_{t,t}; x_{t,t+1}; x_{t,t+2}; \dots; x_{t,2006}$.

$z_{t,i,j}(t+k)$ = the citations in year $t+k$ of paper i , written by economist j in year t .

$t_{d,j}$ = death year of economist j .

Figure 3 provides a hypothetical example illustrating the construction of our “missing citation” measure. Suppose that an author wrote a paper i in year zero ($t = 0$), four years before the author’s death ($t_d = 4$). The actual citation index of the paper is plotted by the bold curve, C_i . The citation curve of “an average paper” written in year zero is the solid curve, AC . To start, we estimate an index of the prominence of paper i relative to the “average paper” written in $t = 0$. This is done by evaluating the position of the paper’s citations [C_i curve] relative to the average citations [curve AC] before the author’s death. Specifically, we estimate the magnification value h_i that minimizes the average squared distance between the magnified curve, $AC * h_i$ and the citation curve C_i , prior to author’s death, $t = t_d$ (i.e., we find $h_{i,j}$ that solves $MIN \sum_{k=0}^{t_d-j} [z_{t,i,j}(t+k) - h_{i,j}x_{t,t+k}]^2$). In the example outlined in Figure 3, $h_i = 2$: prior to author’s death, paper i was cited on average twice as much as an average paper written in the same year, $t = 0$. Had the author stayed alive, the predicted citations of paper i would have been twice the citations of the average paper written in year $t = 0$. We project “the predicted citation curve” had the author’s been alive by plotting the magnified average citation curve, $AC * h_i$, post the author’s death year. We denote this curve by PC_i [see the dotted top curve]. The distance between the “the predicted citation curve” and the actual citations of paper i , post author death [$PC_i - C_i$ for $t > t_d$] provides us with the “missing citations curve,” MC_i . Figure 3 portrays the case where the citations post author’s death dropped by 75%, hence curve MC_i corresponds to $AC * 1.5$ for $t > t_d$. The area below curve MC_i provides us with our estimate of the missing citations.

More precisely, the missing citation curve is constructed in the following way:

For a paper i written at year t by author j , we find the magnification factor $h_{i,j}$ that minimizes the average squared distance between the paper's citations $z_{t,i,j}$, and $h_{i,j}x_{t,t+k}$, (i.e., the citation curve of papers written in year t times the magnification factor), from time t to one year past the author's death, (between year t and year $t_{d,j} + 1$). This is akin to regressing $z_{t,i,j}$ on the average citation curve, $x_{t,t+k}$, prior to $t_{d,j} + 1$, hence

$$(1) \quad h_{i,j} = \frac{\sum_{k=0}^{t_{d,j}-t+1} [x_{t,t+k} z_{t,i,j}(t+k)]}{\sum_{k=0}^{t_{d,j}-t+1} [x_{t,t+k}]^2}.$$

The "missing citations" index for paper i , written at year t , by author j , $M_{t,i,j}$, corresponding to the area below curve MC_i , is defined by $M_{t,i,j} = \sum_{k=t_d-t+2}^{2006-t} [h_{i,j}x_{t,t+k} - z_{t,i,j}(t+k)]$. The "Avg. Missing citations of author j ," AM_j is calculated as the average of $M_{t,i,j}$ for all author's j papers in our sample, and is provided in Table 1. It varies widely; between close to 10 citations per paper, to negative numbers for authors whose research gained growing prominence after their premature death.⁴

The sum of all the missing citations written by author j at time $t+k$ is obtained by adding vertically the "missing citations" curves, $h_{i,j}x_{t,t+k} - z_{t,i,j}(t+k)$. Figure 4 plots the average missing citation curves for four scholars. The top curves [Figure 4a] correspond to authors where the curves suggest sizeable "missing citation" effect post author's death. The bottom curves [Figure 4b] corresponds to Nobel prize-caliber authors, whose citations took off well before their death, and where the growing recognition of their seminal contributions is reflected by negative "missing citations."

The missing citations ratio of paper i , denoted by $mcr_{t,i,j}$, is calculated as

⁴ Our approach is based on matching the citations of each paper in our sample to the pattern of citations of the average paper of the same vintage, allowing for the quality adjustment described in the construction of the magnification factor, $h_{i,j}$. Needless to say, this is only one possible matching strategy out of wide array of possibilities. Yet, because we deal with highly heterogeneous sample of productive economists, it seems to be a reasonable benchmark.

$$(2) \quad mcr_{t,i,j} = \frac{\sum_{k=t_d-t+2}^{2006-t} [h_{i,j}x_{t,t+k} - z_{t,i,j}(t+k)]}{\sum_{k=0}^{2006-t} z_{t,i,j}(t+k)}.$$

The average missing citations ratio [amrc] is calculated as the average of $mcr_{t,i,j}$ for all author's j papers in our sample, and is reported at the last column of Table 1. It varies considerably, from more than 1 [corresponding to the case where the missing citations exceed the total citations] to negative values.

Next, we apply regression analysis to quantify the impact of the "citation death tax." First, we run 16 author specific regressions, where we evaluated the degree to which the missing citation rate index of paper i written at time t is negatively associated with the time between paper's publication and author's death. Table 2 summarizes the 16 regression results for the following specification:

$$(3) \quad mcr_{t,i,j} = c_j + a_{1,j}(d_j - p_{i,j})$$

where $d_j - p_{i,j}$ is the death year of scholar j minus the publication year of paper i , and c_j is a constant, estimating the lost citation index for a paper published at the year of author's death. The value of $a_{1,j}$ reflects the annual cost of lost citations per paper due to premature author's death. The constant term turned out to be significant for half of the authors, having values ranging between 0.7 to about 3. These results hold both with and without self citations. Table 3 reports the results of pooled regressions, akin to (3). Pooling the 8 authors whose "lost citations" coefficients [c_j in (3)] are significant, we find that the annual cost of lost citations per paper due to premature death for these authors is $a_1 = -0.07$, and is highly significant ($t = -5.3$). Hence, a paper written seven years before the author's death avoids a citation cost of about 50%. Similar results apply for a pooled regression of all the 16 authors, and for a pooled regression of all the authors without the two Nobel caliber scholars, Black and Tversky. In an attempt to evaluate the degree to which co-authors play a role in mitigating the death citation tax, we added controls for co-authors [the number of co-authors for each paper, and a measure of the co-authors prominence]. Intriguingly, we failed to detect any systematic co-authors effect.⁵

⁵ The absence of the co-author/s effect may be consistent with the CRS of co-authorship reported by Sauer (1988), who found that individual return from co authoring a paper with n authors is $1/n$ that of a single authored paper.

3. Robustness checks and interpretations

We conducted numerous robustness checks, not reported in the paper. First, we added death year and publication year specific effects to the regressions, and found that the main results continue to hold. We also confirm that the results are not affected by controlling for the large increase over time in the number of papers in Economics [this was done by deflating the citations at time t by the intertemporal scale factor, $I(t)$]. We verified that our results hold with and without self-citations. As a reconfirmation of our methodology, we tested the degree to which the relative skewness of the citations of a paper in our sample is negatively associated with the time elapsed between paper's publication and author's death. This was done by running regressions similar to the one in equation (3), when the LHS variable is the skewness of the citations of a paper in our sample relative to the average citations of papers of the same vintage, properly adjusted for the quality of the paper. The results validated our prior: the citations of papers of the eight authors that were found to be exposed to sizable citation death tax are also characterized by positive skewness of their citations relative to the average citations of the same vintage papers. The size of this citation frontloading increases for papers published closer to the author's death.

4. Discussion

Citations play an important role in the presentation of research and in the use of prior knowledge in written work. Citations are frequently used to make reference to theories, arguments or results without replicating them. Many citations put an author's findings or arguments in context using the familiarity of readers with a literature to reduce what needs to be written, printed and read. These citations may be either complimentary or critical. In the terminology of Posner (2000) these are informational citations. In addition to reducing the costs of presentation and explanation, informational citations can help to market a paper by linking it to already well-known works or authors. Making such citations directly benefits the author of the citing article as well as providing a record of the impact of the cited author.

Another reason for citing is to acknowledge the priority of the research of others. Such citations may be made to avoid accusations of plagiarism or false implied claims of creativity. In this case, citation may only be in the interest of the citing author because of the costs of violating standards set by the scholarly community or of being called to task by the author of the prior work. As noted by Posner, priority citations are a subset of informational citations. They add information about the content of the citing article. The distinction is that some priority citations require the threat of enforcement by others

to be made if adding them is costly (for example, not doing so may allow attribution of the prior knowledge to the new author).

Information costs affect the frequency of citation and the rate of depreciation of citations to individual works through network externalities. The more an article is cited, the higher the likelihood that researchers and students will be aware of its existence and content. Citations to better-known works may be more informative, so that more frequently cited works are more likely to be cited further. This network externality was identified by Merton (1968, 1973) as the Matthew effect.⁶

The difference between priority citations and other informational citations is sufficient for considering the motivations to cite. Authors cite for information reasons out of their own self interest. They internalize the net contribution of the citation to their article in the improvement of their work or the lowering of the costs of communication with their readers. A priority citation can have social value or private value to the author of the original work beyond the information benefit realized by the citing author. Social value can be created by publicizing the original research increasing its use by other researchers. This externality arises because personal acquisition of a body of public knowledge is costly. Priority citations require external incentives provided by other scholars, editors or referees.

The informational model of citations is consistent with the life-cycle pattern of citations to the articles in our dataset. The initial rise can be attributed to gestation and publication lags in research that builds on the contribution of an article, as well as to network externalities in citation. The gradual decline in citations with age fits the exhaustion of opportunities to use the paper's content in original ways or the role of creative destruction as the ideas or techniques in the paper are superseded.⁷

Both kinds of citation give rise to the possibility of strategic citation. Citing to curry favor with referees or editors or the use of editorial review to promote one's own work or that of colleagues are possible examples of strategic citation.⁸ Similarly, authors may cite excessively in the hope of

⁶ These do not exhaust the descriptions of citations given in the literature, including other examples in Posner (2000) and Stigler and Friedland (1975).

⁷ The age profile of citations was noted by Price (1965). McDowell (1982) uses the diminishing citation profiles of papers in his study of the depreciation of researcher knowledge in economics.

⁸ We are unable to find empirical studies that assess whether a referee is cited or not affects recommendations to editors. The differences in referee recommendations for double-blind and single-

generating quid pro quo citations. The private value of an informational citation may exceed its social value in communication.

Along with the structure of publication review, the compensation of academic research influences the extent of strategic citing. The authors of journal articles are paid to produce research by universities and similar institutions and are not compensated by other researchers who benefit from their articles. Citations are used, to varying degrees across disciplines, to measure the contribution of a publication and adjust researcher compensation to internalize benefits produced by the researcher's time and effort. The salaries of economists have been shown to rise significantly with cumulative citations by Diamond (1986), Hammermesh, Johnson and Weisbrod (1982), Sauer (1988) and others. Third party compensation for citations gives an incentive for strategic citation behavior because the costs to the citing author are less than the returns to the cited one.

The premature death of an author should lead to a drop in strategic citations to the author's work. However, there can be a reduction in informational citations due to the death of an author as well. To the extent that an author encourages priority citations to his own work, citations may decline. The author's death may contribute to a decline in research on the same topics through the cessation of the author's research and training of students. These are all examples of networking effects. Researchers play a role in promoting their own research simply by being visible to the research community and continuing to press a current research agenda through presentations and follow-up papers.⁹ The empirical results of this paper may evidence either the importance of networking or of strategic behavior in citation in economics or a combination of both. The results do reveal that being there matters for some prominent economists.

blind refereeing found in the randomized experiment by the American Economic Review reported by Blank (1991) suggest referees are swayed by information other than just the content of submissions.

⁹ The literature on citations and networking includes work that studies how networking affects the frequency of citation. Ferber (1988) finds gender differences in citation practices that may be related to networking.

References

- Blank, Rebecca M. (1991), "The Effects of Double-Blind versus Single-Blind Reviewing: Experimental Evidence from The American Economic Review," *American Economic Review*, Vol. 81, No. 5, pp. 1041-1067.
- Cole, Jonathan R. and Stephen Cole (1973), *Social Stratification in Science*, Chicago: University of Chicago Press.
- Diamond, Arthur. M., "What is a Citation Worth?" *Journal of Human Resources*, Vol. 21, pp. 200-215.
- Ferber, Marianne A. (1988), "Citations and Networking," *Gender and Society*, Vol. 2, No. 1, March, pp. 82-89.
- Hamermesh, Daniel S., George E. Johnson and Burton A. Weisbrod (1982), "Scholarship, Citations and Salaries: Economic Rewards in Economics," *Southern Economic Journal*, Vol. 49, No. 2, pp. 472-481.
- Jaffe, Adam and Manuel Trajtenberg (2002), *Patents, Citations, and Innovations: A Window on the Knowledge Economy*, Cambridge, MA: MIT Press.
- Laband David N. and Michael J. Piette (1994) "Favoritism versus Search for Good Papers: Empirical Evidence Regarding the Behavior of Journal Editors" *The Journal of Political Economy*, Vol. 102, No. 1., pp. 194-203.
- Laband David N. and Robert D. Tollison (2000) "Intellectual Collaboration" *The Journal of Political Economy*, Vol. 108, No. 3., pp. 632-662.
- McDowell, John M. (1982), "Obsolescence of Knowledge and Career Publication Profiles: Some Evidence of Differences among Fields in Costs of Interrupted Careers," *American Economic Review*, Vol.72, No. 4, pp. 752-768.
- Merton, Robert K. (1968), "The Matthew Effect in Science," *Science*, 159, pp. 56-63.
- Merton, Robert K. (1973), *The Sociology of Science*, Chicago: University of Chicago Press.
- Palacios-Huerta Ignacio and Oscar Volij (2004) "The Measurement of Intellectual Influence" *Econometrica*, Vol. 72, No. 3. pp. 963-977.
- Posner, Richard A. (2000), "An Economic Analysis of the Use of Citations in the Law," *American Law and Economics Review*, Vol. 2, No. 2, pp. 381-406.
- Price, Derek J. De Solla (1965), "Networks of Scientific Papers," *Science*, 149, pp. 510-515.
- Sauer Raymond D. (1988) "Estimates of the Returns to Quality and Coauthorship in Economic Academia," *The Journal of Political Economy*, Vol. 96, No. 4., pp. 855-866.
- Stigler, George and Claire Friedland (1975), "The Citation Patterns of Doctorates in Economics," *Journal of Political Economy*, Vol. 83, No. 3, pp. 477-507.

Table 1 -- The sample

Author	Birth year-Death year	Age	First year with citation	Sum of time cited (until the end of 2006)	Avg. citations per active year ¹	# of Papers in sample ²	Avg. Missing citations/paper ³	Avg. Missing citations ratio ⁴
Aiyagari, Rao	1951-97	46	1986	389	18.52	19	-3.23	-0.21
Balassa, Bela	1928-91	63	1959	1523	31.73	87	0.83 (-1.29) ⁵	0.53 (0.51) ⁵
Black, Fischer	1938-95	57	1972	4137	118.20	21	-59.25	-0.17
Bruno, Michael	1932-96	64	1963	621	14.11	30	4.63	0.42
Díaz-Alejandro, Carlos	1937-85	48	1966	261	6.37	12	-3.60	0.77
Eckstein, Otto	1927-84	57	1958	454	9.27	16	14.47	0.94
Farrell, Michael James	1926-75	49	1961	1505	32.72	14	9.66 (-76.79) ⁵	1.09 (0.95) ⁵
Goldfeld, Stephen	1940-95	55	1968	384	9.85	24	2.50	0.38
Johansen, Leif	1930-82	52	1961	309	6.72	25	3.67	0.81
Johnson, Harry	1923-77	54	1957	1095	21.90	90	8.34	1.18
Nedungadi, Prakash	1956-95	39	1985	277	12.59	8	-6.36	0.59
Nelson, Daniel	1959-95	36	1991	1037	64.81	10	-28.34	-0.39
Okun, Arthur	1928-80	52	1962	144	3.20	17	6.12	1.36
Phillips, Alban W H	1914-75	61	1957	758	15.16	14	5.82	1.03
Rader, Trout	1938-91	53	1969	102	2.68	12	-0.42	0.07
Tversky, Amos	1937-96	59	1977	5670	189.00	14	-113.57	-0.03

Notes

1. We exclude self citations. “avg.citation rate per active year” is defined as the total citations divided by the years starting from his first citation. e.g, people start to cite Aiyagari’s paper from 1986, therefore the value we used is the total citation 389 divided by 19 and equals 18.52.
2. For “# of Papers in sample” we only include the cited papers which is published before or just one year after the author’s death.
3. “Avg. Missing citations” is calculated as the average of all the estimated missing citations of author’s papers in our sample (see section 2 for further details).
4. “Avg. Missing citations ratio” is calculated as the average of the estimated “Missing citations/Actual citations” for all author’s papers in our sample (see section 2 for further details).
5. This author wrote one outstanding paper cited more than 350, a paper that has not been subject to “death citation tax,” skewing the “average missing citations” from positive to negative. The first number reports the average without this paper, the second with that paper. There are only two authors in our sample whose “Average missing citations” are considerably affected by the exclusions of one outstanding paper.

Table 2 Lost citations OLS regressions

$m_{t,i,j}$ is the ratio of the projected missing citations of paper i , written by economist j at time t , as a fraction of the total citations of that paper [see section 2 for the detailed definition]. The table reports the coefficients of $m_{t,i} = c + a_1(d - p)$, where d_p is the death year minus publication year.

Bold numbers indicate statistical significance of the “c” coefficient at the at the 5% level.

Author	Include All cites			Exclude self cites		
	c (t value)	d_p (t value)	Number of obs.	c (t value)	d_p (t value)	Number of obs.
Aiyagari, Rao	-0.37 (-1.58)	0.04 (1.23)	19	-0.54 (-2.48)	0.06 (1.87)	19
Balassa, Bela	1.12 (6.59)	-0.04 (-4.11)	90	1.10 (6.21)	-0.04 (-3.86)	87
Black, Fischer	-0.36 (-2.18)	0.015 (1.40)	21	-0.36 (-2.18)	0.015 (1.38)	21
Bruno, Michael	0.75 (3.61)	-0.02 (-1.81)	31	0.76 (3.60)	-0.02 (-1.82)	30
Díaz-Alejandro, Carlos	0.90 (1.49)	-0.02 (-0.27)	12	0.9 (1.49)	-0.02 (-0.27)	12
Eckstein, Otto	2.01 (2.03)	-0.07 (-1.27)	17	2.00 (1.96)	-0.07 (-1.20)	16
Farrell, Michael James	3.0 (2.98)	-0.19 -2.27	14	3.01 (2.98)	-0.19 -2.27	14
Goldfeld, Stephen	0.93 (3.88)	-0.03 (-2.38)	24	0.81 (3.16)	-0.03 (-1.85)	24
Johansen, Leif	2.83 (2.69)	-0.14 (-1.65)	26	1.31 (2.06)	-0.05 (-1.01)	25
Johnson, Harry	2.40 (4.83)	-0.14 (-2.91)	91	2.40 (4.81)	-0.14 (-3.00)	90
Nedungadi, Prakash	0.78 (0.84)	-0.03 (-0.24)	8	0.80 (0.85)	-0.04 (-0.25)	8
Nelson, Daniel	-0.45 (-1.15)	0.12 (0.88)	10	-0.61 (-2.37)	0.12 (1.36)	10
Okun, Aurthur	1.85 (2.09)	-0.07 (-0.68)	17	1.85 (2.09)	-0.07 (-0.67)	17
Phillips, A W H	2.75 (1.45)	-0.15 (-1.04)	14	2.75 (1.45)	-0.15 (-1.04)	14
Rader, Trout	0.07 (0.22)	0.00 (0.19)	13	-0.25 (-0.56)	0.02 (0.76)	12
Tversky, Amos	0.15 (0.47)	-0.02 (-0.48)	14	0.02 (0.04)	-0.01 (-0.20)	14

Table 3 Pooled regressions

$m_{t,i,j}$ is the ratio of the projected missing citations of paper i , written by economist j at time t , as a fraction of the total citations of that paper [see section 2 for the detailed definition]. The table reports the coefficients of pooled regressions of $m_{t,i} = c + a_1(d - p)$, where $d - p$ is the death year minus publication year.

Author	Include All cites			Exclude self cites		
	c (t value)	d_p (t value)	Number of obs.	c (t value)	d_p (t value)	Number of obs.
Pooling regression without author dummies						
With 8 authors (the authors reported in table 2 with significant citation death tax, "c")	1.83 (8.98)	-0.08 (-5.64)	309	1.64 (8.69)	-0.07 (-5.34)	303
With 14 authors (without Black and Tversky)	1.45 (8.31)	-0.06 (-4.78)	385	1.28 (7.82)	-0.05 (-4.34)	378
With all 16 authors	1.29 (8.01)	-0.05 (-4.52)	420	1.13 (7.46)	-0.04 (-4.04)	413
Pooling regression with author dummies						
With the 8 authors (the authors reported in table 2 with significant citation death tax, "c")	Not report	-0.07 (-4.69)	309	Not report	-0.06 (-4.48)	303
With 14 authors (without Black and Tversky)	Not report	-0.07 (-4.87)	385	Not report	-0.06 (-4.59)	378
With all 16 authors	Not report	-0.06 (-4.78)	420	Not report	-0.05 (-4.46)	413

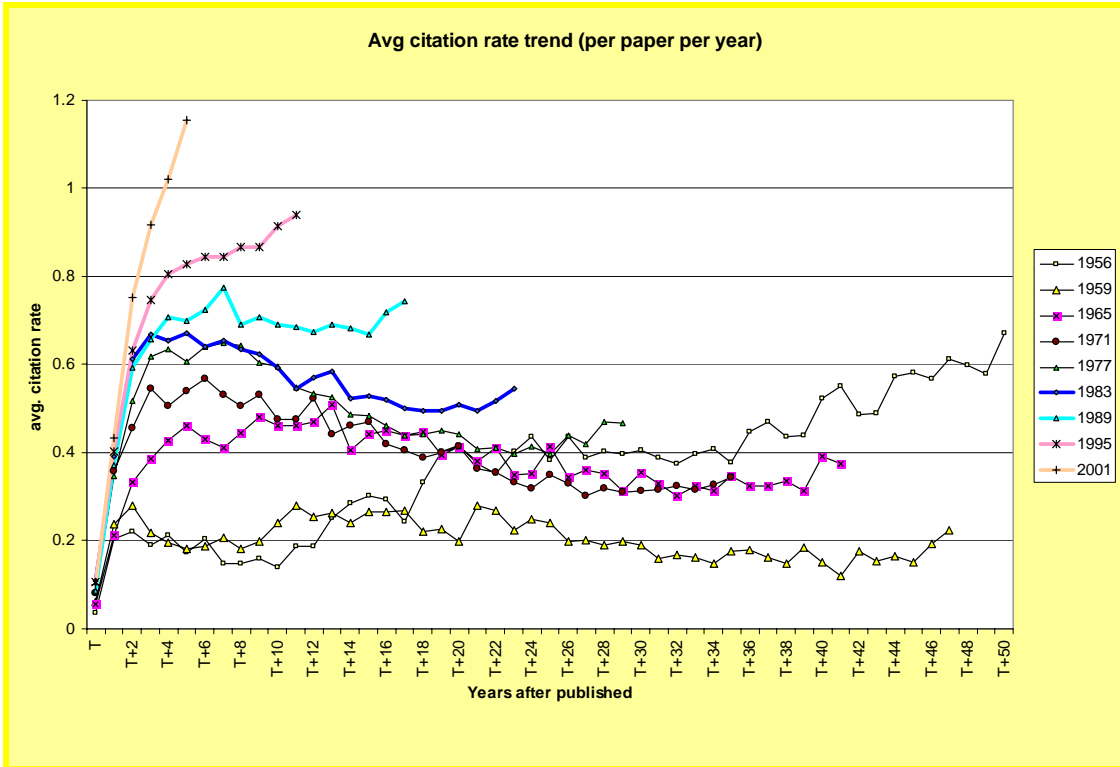


Figure 1a Average citations per paper written in year t , for papers with at least one citation, cited by papers written in year T , $T+1$, $T+2$ for selected years. The samples are restricted to economics articles written in English, appearing in the SSCI database.

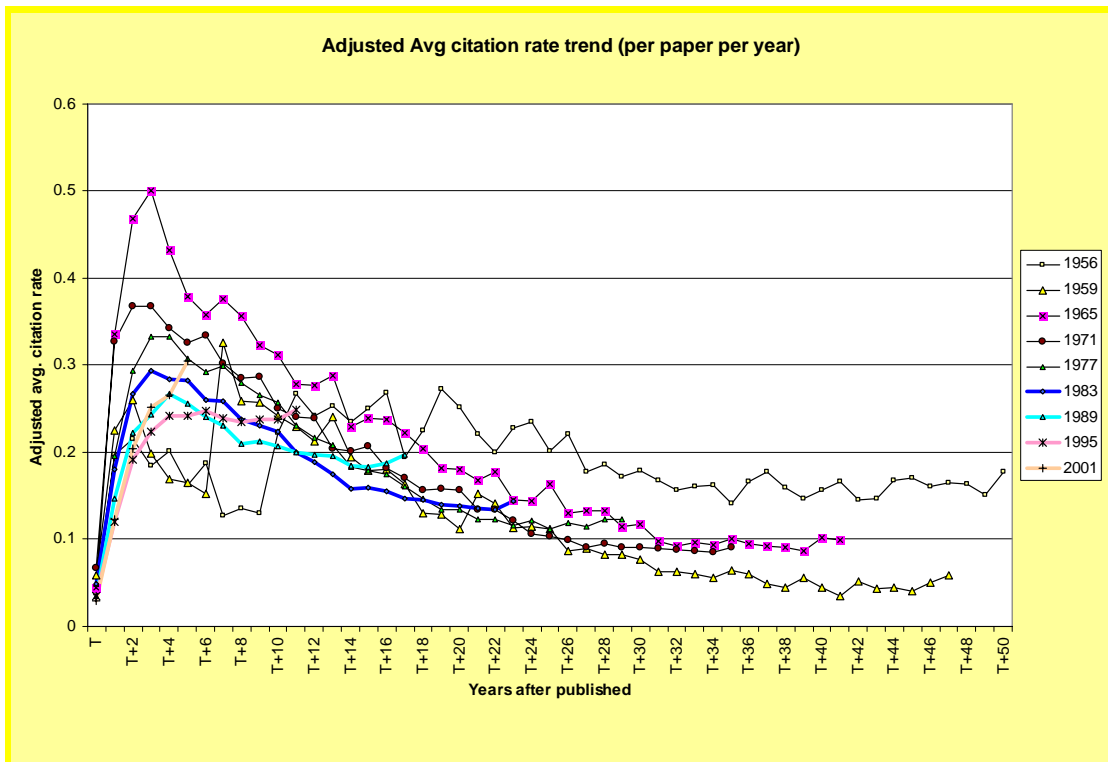


Figure 1b Average citations per paper written in year t , for papers with at least one citation, cited by papers written in year T , $T+1$, $T+2, \dots$ for selected years, normalized by size index $I(t)$

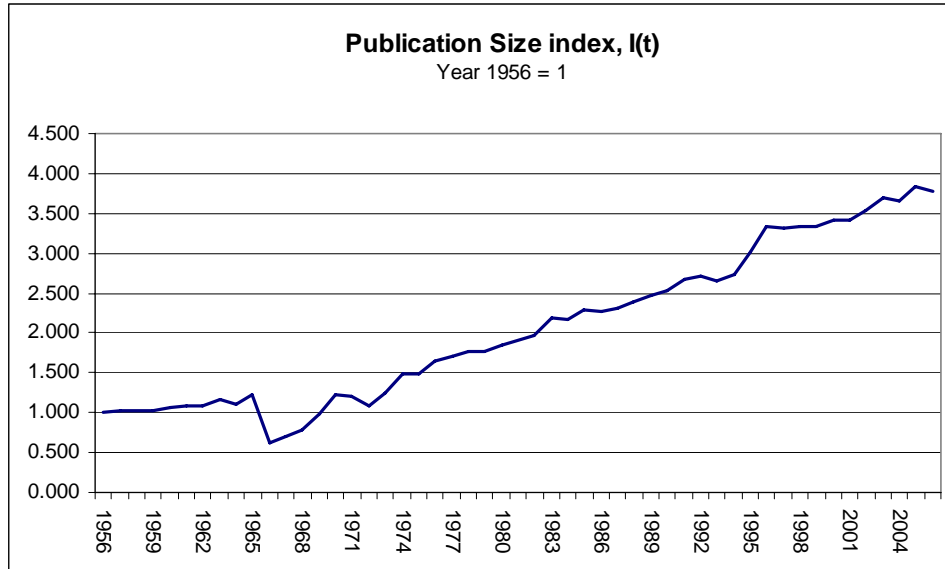


Figure 2: Publication size index $I(t)$, number of papers in economics publish in year t /the number of papers in economics published in 1956

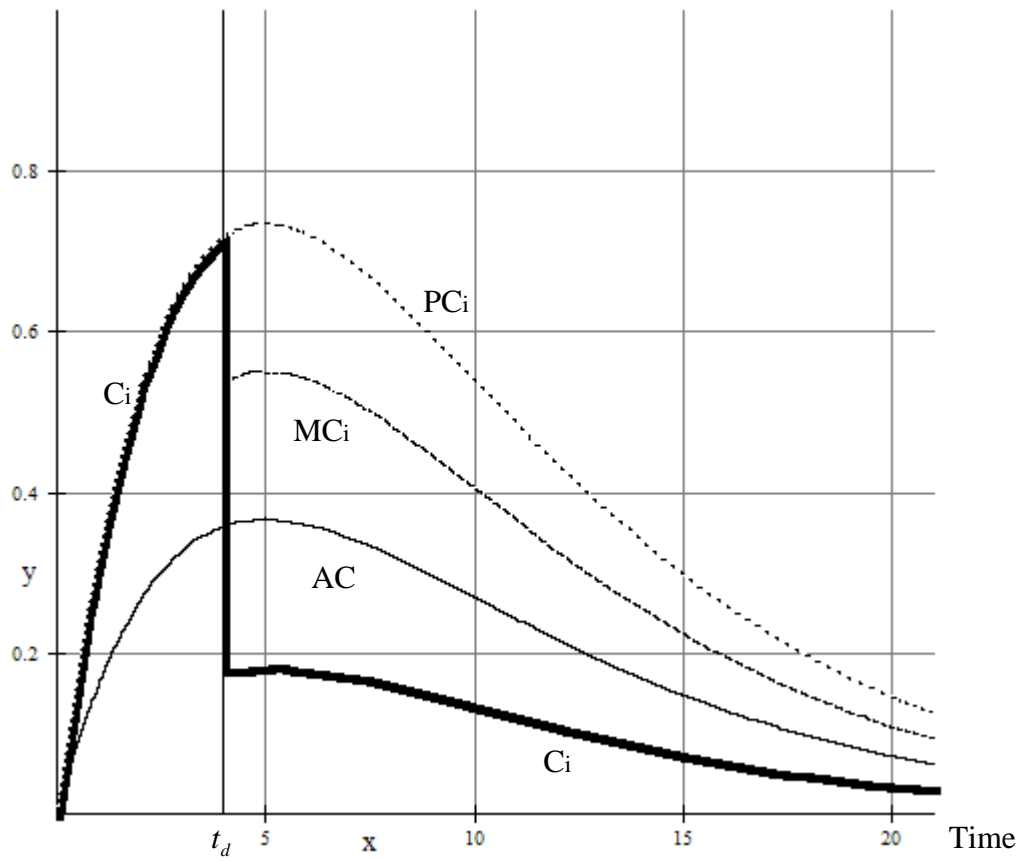


Figure 3: Stylistic illustration of constructing the missing citation curve

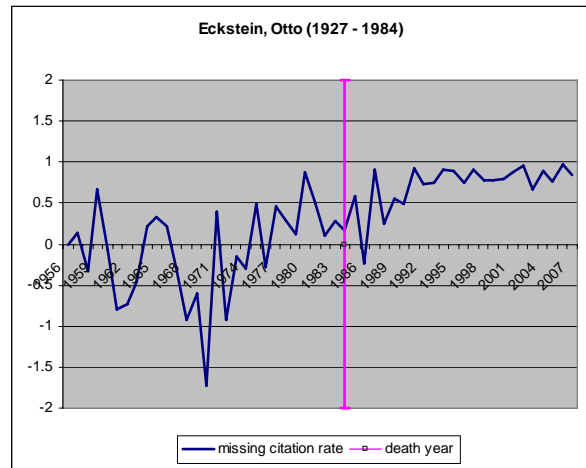
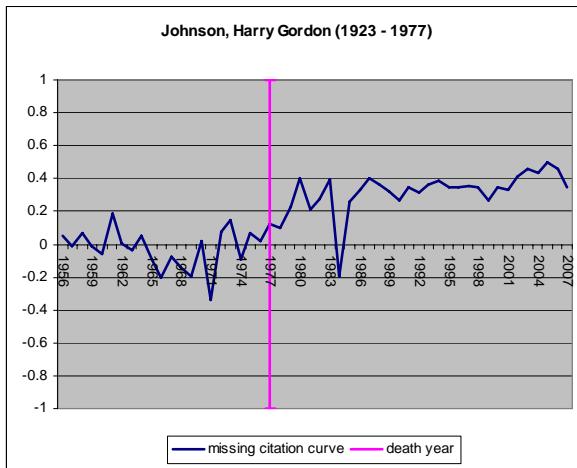


Figure 4a: “Average missing citation” curves for two scholars.

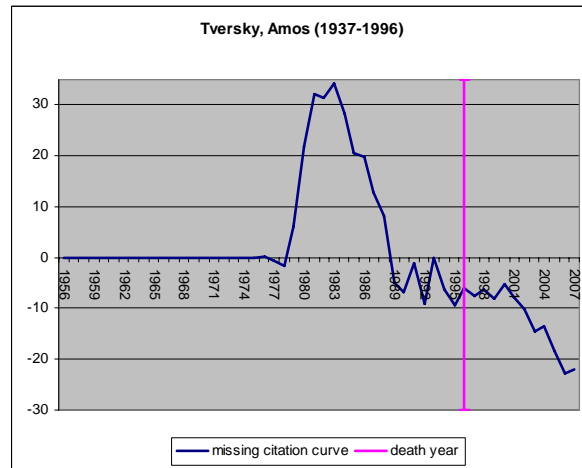
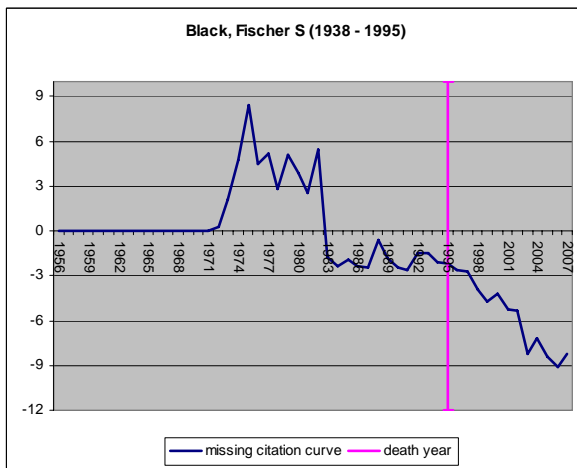


Figure 4b: “Average missing citation” curves for two Nobel Prize-caliber scholars – no “citation death tax” effect

Estimated missing citations/published papers at year T for author j: $\sum_{i=1}^n [h_{i,j} \cdot x_{t,T} - z_{t,i,j}(T)] / n$ [see section 2 for the detailed definition].