

Age, Cohort and Co-authorship: The Statistics of Collaboration

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The previously documented trend toward more co- and multi-authored research in economics is partly (perhaps 20 percent) due to different research styles of scholars in different birth cohorts (of different ages). Most of the trend reflects on profession-wide changes in research style. Older scholars show greater variation in their research styles than younger ones, who use similar numbers of co-authors in each published paper; but there are no differences across cohorts in scholars' willingness to work with different co-authors. There are only small gender differences in the impacts of age on numbers of co-authors, but substantial differences on choice of co-authors. I offer advice to aging economists on aiding their junior co-authors.

5.1 BACKGROUND

In medicine and the natural sciences it has long been *de rigueur* for scientific articles to list numerous co-authors (Zuckerman 1977). In economics co- and multi-authorship are increasingly the norm, as shown through the

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Table 5.1 Distribution of full-length refereed articles by co-authorship status, *AER*, *JPE* and *QJE*, 1963–2011*

Year	Number of articles	Distribution of number of authors			
		$Pr\{2+\}$	$Pr\{3 2+\}$	$Pr\{4 3+\}$	$Pr\{5 4+\}$
1963	86	0.163	0.000	0.000	0.000
1973	119	0.286	0.029	0.000	0.000
1983	125	0.456	0.140	0.000	0.000
1993	136	0.551	0.280	0.095	0.000
2003	135	0.741	0.280	0.214	0.000
2011	147	0.796	0.385	0.222	0.200

*Includes all full-length original articles, except Nobel and Presidential addresses. Calculated from Table 2 of Hamermesh (2013)

1970s by McDowell and Melvin (1983) and through the early 1990s by Hudson (1996) and Laband and Tollison (2000). Especially noteworthy is the acceleration of co-authorship in economics since then. Consider the evidence in Table 5.1 (reproduced from Hamermesh 2013), showing patterns of co-authorship in the three leading general journals in economics—the *American Economic Review*, the *Journal of Political Economy* and the *Quarterly Journal of Economics*. In the 1960s a jointly authored paper was a rarity; today in these leading outlets it is standard. Moreover, these summary statistics show that the distribution of the number of authors of a paper in these journals has shifted monotonically rightward, so that today having four or more authors on a paper in these top journals is quite common.

Along with this growth in the number of authors on published papers in economics has come a surprising shift in the age distribution of those authors. From the 1960s through the early 1990s top-flight publishing in economics appeared to be a young person’s “game.” As Table 5.2 shows, beginning in the 1990s there was a sharp increase in the fraction of articles that included older co-authors. While the nearly 20 percent of co-authors ages 51 and over is still below the fraction of academic economists in that age range (Hamermesh 2013), the distribution of ages of those publishing in these journals is much closer to their representation in the relevant population today than it was in the last half of the twentieth century.

This striking change in the age patterns of publishing and the increasing presence of older authors make a positive examination of the relationship

Table 5.2 Percent distributions of age of authors, top three general economics journals, 1963–2011*

<i>Year</i>	<i>Age Distribution of Authors</i>		
	≤35	36–50	51+
1963	50.5	45.3	4.2
1973	61.5	32.6	5.9
1983	48.5	47.2	4.3
1993	49.8	43.1	7.1
2003	36.8	50.4	12.8
2011	33.0	48.1	18.9

*Includes all full-length original articles, except Nobel and Presidential addresses. Age could not be found for three authors in 1963, one author in 1973. The distributions are weighted by the inverse of the number of authors in the publication. Calculated from Table 1 of Hamermesh (2013)

between aging and co-authoring interesting. Also, my personal interest in aging and co-authorship (as a 71-year-old still trying to publish in refereed outlets) makes this topic personally attractive. So too, perhaps comments based on my experience in co-authoring may be useful to other older economists—and to their juniors who may co-author with them.

In this chapter, I therefore examine several sets of data that I have assembled on patterns of co-authoring to discover some new facts about the relationship between co-authoring and age among economists. I focus on the determinants of the trend in co-authorship in relation to age and on the interactions among co-authors—the differences in age among them and the persistence of co-authoring relationships as careers progress. Based on my personal experiences, I finish by offering some advice to older economists that might help them advance the careers of the younger scholars with whom they work and have the additional benefit of offering a self-control mechanism that might enable them to avoid being viewed as senescent limelight-hogs by their colleagues.

5.2 AGE, COHORT OR TIME?

Is the growth of co-authorship in economics publishing specific to the times? Does it result from the predominance among those currently publishing of scholars who came of age in the 2000s? Or does it stem from the effect of aging on scholars' behavior? This last possibility seems

unlikely from the cross-section evidence above, since regression estimates in Hamermesh (2013) showed that scholars ages 51+ are no more likely than much younger scholars to publish co-authored works in the very top journals in the field. But that comparison does not allow us to examine this possibility seriously. To distinguish cohort effects from time effects, we need to obtain longitudinal data describing individuals' careers from their beginning until, where possible, advanced age (as pointed out by Borjas 1985, in the analogous case of the time paths of immigrants' earnings relative to natives').

As a start to examining this issue I provide an anecdote—my own publishing history. By my count I have published 118 journal articles in my career, beginning in 1966 and going through 2013, of which 54 (46 percent) were co-authored (with 52 different individuals). During the first half of my career thus far (24 years, 1966–1989), 12 of the 40 papers published (30 percent) were co-authored; during the second half (1990–2013) 42 out of the 78 published papers (54 percent) were co-authored. These longitudinal data ($N = 1$, $T = 48$) are obviously not drawn from a random sample. If, however, one makes the giant leap to assuming that one economist's professional life is a random sample from the population of all economists, a test of the difference in publishing behavior over these two halves of my career rejects the hypothesis that these two fractions are equal ($t = 3.79$).¹

As Zvi Griliches once remarked to me, “The plural of anecdote is data.” To go beyond anecdote and examine these issues seriously, I have collected the publication records of all the economists ages 80 or under who were alive on January 1, 2014, and who are or were either: (1) Fellows of the Society of Labor Economists; and/or (2) Winners of the Institute for the Study of Labor (IZA) Prize in Labor Economics or its Young Labor Economist Award. This population of awardees—this sample of labor economists—consists of 83 scholars, of whom I excluded four because I could not obtain *curricula vitae* that were less than four years old. The remaining sample members were born between 1933 and 1980.

The analysis is based on a highly selected sample of 79 people from the population of all scholars who might be classified as labor economists. It includes three Nobel Prize winners, five Past Presidents of the American Economic Association or the Royal Economic Society, six winners of the John Bates Clark Medal or its European equivalent (the Yrjö Jahnsson Award) and 37 who are also Fellows of the Econometric Society (and who include all members of the first three groups as subsets).

The data set contains information on 3968 articles published in journals by these 79 people up through early 2014. In constructing the data set I included both refereed and non-refereed publications, although the overwhelming majority of papers apparently consist of refereed papers. Notes, comments, Presidential/Nobel lectures and so on are all included, so long as they were published in a journal outlet. For each paper we collected the names of all authors listed on the paper, right-truncating (in two cases) at seven authors. The 79 authors' names are listed in the Appendix.

Unlike the samples underlying Tables 5.1 and 5.2, which include all authors regardless of their distinction who published in the most prestigious outlets in the economics profession in several particular years, this sample contains all the journal publications by a distinguished sample of authors. Thus as a first check on this new sample I examine whether the pattern of increasing co-authorship over time that was shown in Table 5.1 also prevailed here. Data describing the numbers and frequency distributions of journal articles published by these scholars in each of the same six decades as in Table 5.1 are presented in the upper panel of Table 5.3.

These data show very similar patterns of co-authorship to those in Table 5.1. The fraction of co-authored papers rose from around two-fifths in the 1960s and 1970s to five-sixths in the 2010s. These fractions are slightly above those in the first column of Table 5.1, but the rise in

Table 5.3 Distribution of Journal Articles by Co-authorship Status, 79 Labor Economists, 1964–2014, and Descriptive Statistics—Means, Standard Deviations and Ranges

<i>Year</i>	<i>Number of articles</i>	<i>Distribution of number of authors</i>			
		<i>Pr{2+}</i>	<i>Pr{3+ 2+}</i>	<i>Pr{4+ 3+}</i>	<i>Pr{5+ 4+}</i>
1960s	33	0.424	0.000	0.000	0.000
1970s	338	0.328	0.129	0.067	0.000
1980s	741	0.587	0.195	0.165	0.357
1990s	1081	0.717	0.289	0.156	0.143
2000s	1273	0.739	0.451	0.267	0.265
2010s	502	0.833	0.660	0.308	0.412

<i>Birth year</i>	<i>Ph.D. year</i>	<i>Age when published</i>	<i>Number of articles</i>	<i>Age at Ph.D.</i>
1956	1984	45.2	50.3	27.9
(12.9)	(13.8)	(10.9)	(35.7)	(2.2)
[1933, 1980]	[1962, 2012]	[21, 79]	[3, 184]	[24, 35]

co-authorship is of similar size. The differences in levels may arise from the nature of research in what is predominantly an empirical sub-specialty and from the broad range of quality of the journals in which these scholars' articles are published.

Even beyond matching the secular change in the pattern of co-authorship, these data replicate the increasing fraction of multi-authored (3+ authors) papers conditional on any co-authorship. While the incidence of co-authorship rose sharply after the 1970s, the incidence of multi-authorship increased monotonically across the decades in this sample, so that in the 2010s a majority of these authors' publications were part of at least three-author collaborations. Indeed, in the current decade over one-sixth of their publications contain four or more authors.

The criteria for inclusion in the sample are based partly on career distinction, so that unsurprisingly the mean age of the sample members in 2014 is quite high—58. As the lower half of Table 5.3 shows, however, the mean age when the articles in the sample were published was only 45. The 58-year range in authors' ages at time of publication ensures that we have enough sampling variation to examine the relationship among the incidence of co-authorship, trends and aging. The average age when these authors obtained their Ph.D. degree was 28, but here too there is substantial variation: The age ranges from 24 to 35.²

The average number of journal articles published up through early 2014 in this sample was 50. Of course, the more senior members of the sample had published more articles, but even within age groups there are large differences in rates of publishing activity. Thus the 39 authors ages 60+ in 2014 had published an average of 65 papers, with a range of 20–184 journal articles, while those under age 50 in 2014 (21 of the authors) had published an average of 19 papers, with a range of 3–101. In short, there is substantial sampling variation among these authors, even within the same age cohort, and even at the same calendar time.

Having shown that co-authorship and multi-authorship have risen in this sample, as in articles published in the top journals, we can use these data covering entire careers to examine whether their incidence has risen with age over these authors' careers. As a first step consider the results in Figs. 5.1 and 5.2, showing the relationship between authorship and birth year. They make it completely clear that co- and multi-authorship are more prevalent among scholars in more recent birth cohorts.³

That there has been an increase over time in the fraction of co-authored and multi-authored articles is well known and clear from both of the data

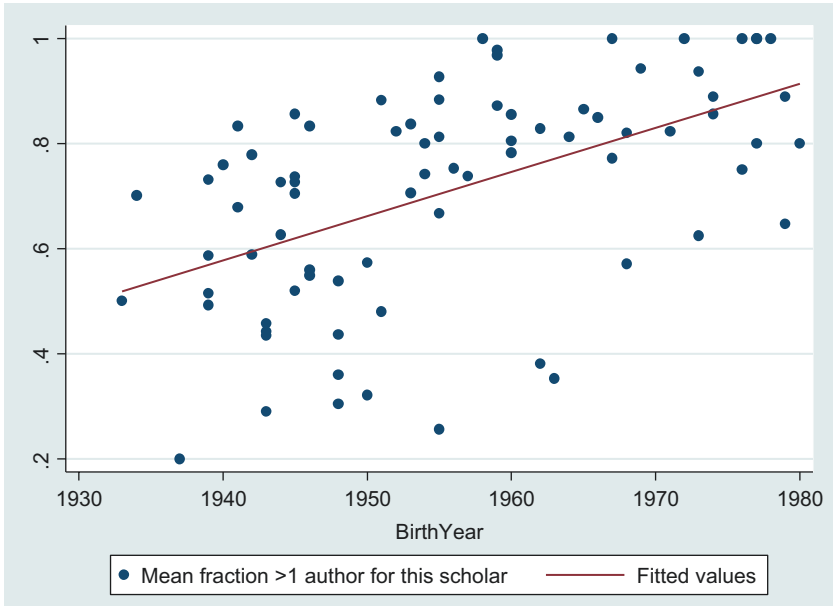


Fig. 5.1 Relation between birth year and co-authorship, $N = 79$

sets used in this study. Is this a general trend? Is it due to the increased fraction of older authors among publishers (since, as Table 5.2 showed, there has been a sharp increase in the fraction of older economists among authors of articles in leading journals), and authors have tended to do more co-authoring as they have aged. Or is it a cohort effect, with authors in more recent cohorts being more likely to co-author at the same age as authors from earlier cohorts?

Let C_{iat} be an indicator of a publication having been co-authored, where i is a publication, a is an indicator for the author (from among the 79 in this sample), and t represents the year. (A similar equation could be written for the number of authors on a paper.) Let AGE_{at} be author a 's age in year t , and $BIRTHYEAR_a$ be author a 's birth year. Then we can estimate any of the following three equations:⁴

$$C_{iat} = \alpha_0 + \alpha_1 t + \alpha_2 AGE_{at} + \varepsilon_{iat} \quad (1a)$$

$$C_{iat} = \beta_0 + \beta_1 t + \beta_2 BIRTHYEAR_a + \xi_{iat} \quad (1b)$$

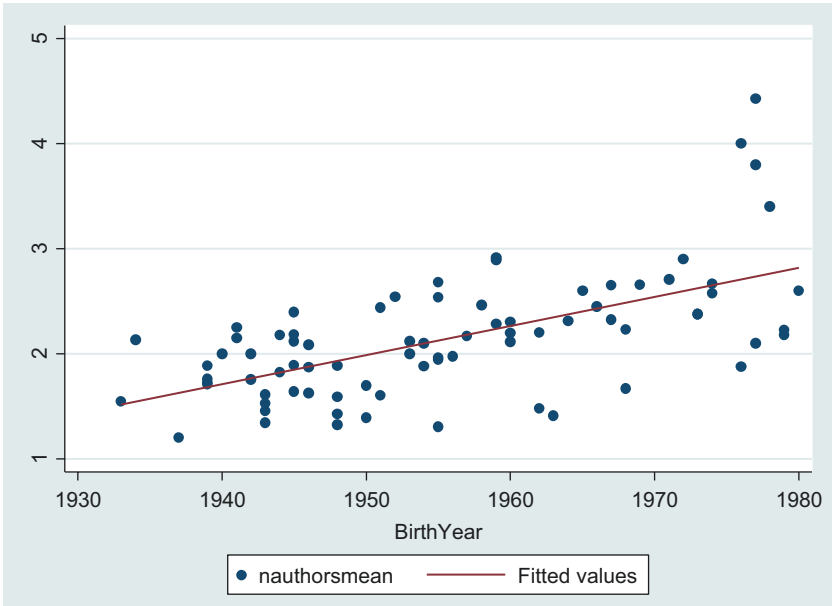


Fig. 5.2 Relation between birth year and average number of authors, $N = 79$

or

$$C_{iat} = \gamma_0 + \gamma_1 \text{BIRTHYEAR}_a + \gamma_2 \text{AGE}_{at} + v_{iat}, \quad (1c)$$

where, the α , β and γ are parameters, and the ε , ξ and ν are random error terms. Because of the identity:

$$t \equiv \text{AGE}_{at} + \text{BIRTHYEAR}_a, \quad (2)$$

we cannot identify time, age and cohort effects separately; but we can identify the parameters in any of the three pairs implied by the variables included in equations (1). Since the literature has stressed the secular rise in co-authorship, I estimate only (1a) and (1b), implicitly assuming that there is a trend effect and trying to examine how much of the effect that is measured when α_2 or β_2 is set equal to 0 is due to differential behavior across cohorts or with age.

Before estimating (1a) and (1b), much of what might be inferred from the estimates of (1b) is discernable from the statistics in Table 5.4. The first three columns describe the publishing activities of the 34 authors in the earliest cohort (Ph.D. received before 1980) in each of three time periods: 1962–1979, 1980–1999 and 2000–2014. Within this cohort, the propensity to co-author increased over time, as did the propensity to be involved in multi-authorships. The same increase is visible in columns (4) and (5) for the 29 scholars in the 1980–1999 Ph.D. cohort. Comparing columns (2) and (4), or columns (3) and (5), the table also shows that during the same time period scholars from the earliest cohort were less likely than scholars from the middle cohort to co-author or be one of multiple authors. The point is demonstrated even more strongly by adding the statistics in column (6) to this comparison: The 16 members of the most recent cohort (Ph.D. received between 2000 and 2012) are even more likely than scholars in either of the two earlier cohorts to have published co-authored articles, and even more likely to have multiple authors listed on their papers, between 2000 and 2014.

The comparisons suggested by Table 5.4 are borne out by the results of probits and ordered probits describing the propensity for co- and multi-authorship that are presented in Table 5.5. Throughout I present the probit derivatives describing co-authorship and cluster standard errors on the authors.⁵ The equations also include indicators for the decade in which the article was published, thus expanding α_1 and β_1 into vectors of parameters and taking into account what Table 5.3 suggested were discrete increases

Table 5.4 Descriptive statistics of articles, 79 labor economists, 3968 articles, by date published and author's Ph.D. Cohort

<i>Authors</i>	<i>Author Ph.D. Year</i>			<i>Year Published*</i>		
	<i>1962–1979</i>	<i>1980–1999</i>	<i>2000–2014</i>	<i>1962–1979</i>	<i>1980–1999</i>	<i>2000–2014</i>
1	62.2	39.6	34.4	22.9	16.2	15.1
2	33.8	46.3	34.9	55.2	39.8	33.6
3	3.7	12.0	21.6	18.3	31.8	37.1
4	0.3	1.5	6.6	3.2	7.9	9.3
5+	0	0.6	2.5	0.5	4.3	4.9
No. of articles	370	1168	717	652	853	205
No. of authors	34	34	34	29	29	16

*Three of the 3968 articles in the sample are excluded here. One was published in 1979 by a scholar who received the Ph.D. in 1983, and two were published in 1999 by a scholar who received the degree in 2000

Table 5.5 Estimates of the determinants of the number of authors of Journal Articles, 79 labor economists, 3968 articles, 1964–2014*

Equation	<i>Co-authored</i>			<i>No. of Authors</i>		
	<i>Probit derivatives</i>			<i>Ordered probit coefficients</i>		
	(1a)	(1b)		(1a)	(1b)	
Ind. Var.						
Age	–	–0.0051 (0.0018)	–	–	–0.0090 (0.0045)	–
Birth year	–	0.0062 (0.0019)	–0.0322 (0.0107)	–	0.0128 (0.0047)	–0.0580 (0.0262)
Ph.D. year	–	–	0.0375 (0.0103)	–	–	0.0684 (0.0250)
	0.059	0.062	0.076	0.053	0.055	0.060

*All equations include a vector of indicators of the decade in which the article was published, with the 1960s as the excluded decade. Standard errors are clustered on the authors

in the propensity for co- and multi-authorships in the 1980s, the 1990s and the 2010s.⁶ The estimates of (1a) indicate that in a given decade older economists were less likely to write co- or multi-authored articles, while the estimates of (1b) show that scholars in the earlier cohorts were also less likely than their younger colleagues to publish such work.⁷

Adding author fixed effects to the estimates in columns (1) and (4) and including a quadratic in age does not change these conclusions. Indeed, over a 47-year interval of a scholar's journal publications (the longest that is observed in these data—for two authors in the sample) the expected incidence of co-authorship would have risen by 25 percentage points. The quadratic terms are important—the rate of increase of co-authorship slows with age, as does the rate of growth in the number of authors listed on these scholars' articles. But even with the deceleration in these phenomena as the scholars age, the incidence of co-authorship in the sample only stops increasing after age 62, while the estimated number of authors never decreases with age within the sample range of ages.

Assuming that there is some trend in co-authorship, the identity in (2) prevents us from extricating cohort from aging effects in this trend. We can, however, infer how much of the gross upward trends in co- and multi-authorship are due to aging and/or cohort effects in this sample by comparing the estimate of β_1 with and without β_2 constrained to equal zero. Concentrating on the propensity for co-authorship, and estimating

(1b) with only a time trend, the estimated probit derivative $\beta_1 = 0.0102$. With β_2 unconstrained, the estimate of β_1 falls to 0.0079. A reasonable conclusion is that age/cohort effects account for perhaps around 20 percent of the gross trend increase in the propensity to co-author.⁸

While we cannot break the identity in (2), we can take advantage of the fact that authors in the same birth cohort (and thus of the same age in a year when they both published journal articles) earned their Ph.D. degrees in different years. The correlation between birth year and Ph.D. year is, of course, very high (+0.98), but it is not one. I thus re-estimate (1b), expanding the specification to include Ph.D. year. The results when both birth year and Ph.D. year are included in the specification are shown in columns (3) and (6) of Table 5.5. Not surprisingly, the coefficients nearly sum to the estimates of β_2 presented in columns (2) and (5), and their individual significance levels are substantially reduced from those of the earlier estimates. Nonetheless, they do suggest that, given the year when they published and the year when they were born, those scholars who received their Ph.D. degree later in life (who can be viewed as having entered the profession later in life) were more likely to publish co- and multi-authored papers.⁹ This finding suggests that the trends in co- and multi-authorship have something to do with the research styles that one learns from what the profession is doing during one's Ph.D. program or very early in one's publishing career.

A number of other variables might be expected to alter the relationships described in (1).

For example, respondents who have positions in the best economics departments might have more and better Ph.D. students with whom to co-author. Adding an indicator for the top ten economics departments in North America and the top two in the United Kingdom, which describes almost half the 79 respondents, to the estimates in Table 5.5 of Equations (1a) and (1b) never changes the first significant digit of the estimate of the crucial parameter; and the indicator itself, although it enters positively, has t-statistics well below one. Another possibility is that co-authoring practices are different between North America and the rest of the world, and that this difference is correlated with age/cohort. Scholars at North American institutions, who account for five-sixths of the sample, are (nearly significantly) less likely to co-author, and have fewer co-authors when they do, than scholars of the same age at the same time on other continents. Nonetheless, the estimated effects of age or birth year hardly change in size or statistical significance from what is shown in Table 5.5.

Until fairly recently tabulations of citations only recorded the name of the first author of an article; and even now the custom in the text of a published paper is to list no more than two authors, relegating additional authors to inclusion in “et al.” Not wishing to be known as “Al,” and in a discipline where alphabetical order is customary (see Engers et al. 1999), scholars with surnames late in the alphabet may strategically avoid or limit their co-authoring. To examine this possibility I created a variable ranging from 1 for “A” to 23 for “W” in this sample, indicating the numerical position of the first letter of the scholar’s surname, and added it to the estimates of (1a) and (1b). Its inclusion changed the estimated impact of age (birth year) by less than two in the second significant digit, and its own coefficients were unexpectedly positive, although with t-statistics less than one.

Overall the results suggest that cohort effects are important in explaining the observed upward trends in co- and multi-authorship in economics. The dominant component of those trends, however, is general and cannot be attributed to differences in behavior among scholars of different cohorts, or to changes in co- and multi-authorship patterns with age. While the causes of these (about which I speculated in Hamermesh 2013, and which Jones 2009, modeled) are unclear, they are not the result of inherent differences in people’s behavior resulting from aging or from differences among people educated at different times.

5.3 PRIOR CO-AUTHORING AND PRODUCTIVITY

Does having relied more on co-authors in the past alter the relationship between age and publishing productivity? It is difficult to infer causation—to distinguish heterogeneity from state dependence in co-authoring—but we can infer whether those who are more prolific publishers with age have had more previous co-authors. Also, this examination has implications for people’s responses to the incentives to publish.

In the sample of 79 labor economists I measure the years since the most recent prior publication for all but each author’s first published article. Not surprisingly given the distinction of the scholars in this sample, 57 percent of papers appear in years when the author publishes two or more papers; and another 34 percent appear in print the year after another published paper. Nonetheless, 6 percent of the published papers in the sample appeared after a two-year hiatus, 2 percent after a three-year hiatus, and 1 percent after four years, so that there is scope for examining how

the length of time between publications relates to the author's prior co-authoring practice.¹⁰

Estimates of Poisson regressions describing the hiatus between publications are presented in Table 5.6, which gives results that are qualitatively the same as those of estimates of Poisson regressions describing the numbers of publications in a given year.¹¹ In each equation, I include the same vector of indicators of the decade of publication as was included in the estimates shown in Table 5.5. The results in the first column show that there is a negative, but statistically insignificant relationship between time since publication and the author's age. Most important, the estimates in the second and third columns show that having previously published more co-authored or multi-authored papers is associated with a shorter hiatus between publications. The estimates in both columns approach statistical significance.¹²

The positive effect of prior co- and multi-authorship on the frequency of publication might be related to heterogeneity in the sample. For example, it may be that authors from the earlier cohorts in the sample, since I selected them based on substantial lifetime achievement, might have published more frequently at the same age than authors from later cohorts. One way to examine this possibility is to include both age and patterns of prior co- and multi-authorship in the equations. Estimates of these expanded equations are shown in the fourth and fifth columns of Table 5.6. They make it clear that this sort of heterogeneity does not matter: The parameter estimates change only slightly from those in columns (2) and (3), and their statistical significance increases.

The authors in this sample are heterogeneous along a variety of unknowable dimensions. To account for this fact I re-estimate the

Table 5.6 Poisson estimates of the determinants of elapsed time between publications, 1966–2014 ($N = 3889$)*

Ind. Var.					
Age	-0.0072 (0.0066)	-	-	-0.0099 (0.0068)	-0.0100 (0.0070)
Prior average Co-authored	-	-0.3670 (0.2161)	-	-0.4494 (0.2210)	-
Prior Average No. of authors	-	-	-0.1745 (0.1287)	-	-0.2344 (0.1297)
Pseudo- R^2	0.0044	0.0052	0.0045	0.0071	0.0064

*All equations include a vector of indicators of the decade in which the article was published, with the 1960s as the excluded decade. Standard errors are clustered on the authors

equations in columns (2) and (3) including fixed effects for each author, which generates only small changes in the parameter estimates. Overall, the results suggest that having had more co-authors is associated with more frequent subsequent publication. Indeed, given the estimates that are produced when author fixed effects are included, one might even infer that this relationship is causal—that co-authoring makes one more productive (when one defines productivity as a count of the *number* of publications). For a given individual, having had more co-authors up to a particular age leads the scholar to publish more quickly subsequently.

5.4 AGE AND THE CHOICE OF CO-AUTHORS

The choice of co-authors reflects the outcome of a matching process. One chooses co-authors based on such factors as complementarities in production, but perhaps also on one’s personal preferences—how comfortable one feels working with different individuals. While we cannot examine complementarities in production here, in this and the next section we examine how preferences for people “like oneself”—particularly age and gender—are exhibited.¹³

5.4.1 *The Relation Between Age and Co-authors’ Ages*

The data underlying Tables 5.1 and 5.2 can provide an initial look at how the choice of co-authors differs by the age of authors. Consider the statistics in the first row of Table 5.7, showing the mean absolute age differences between co-authors of two-authored articles in these journals by age of author, where each article is counted as one observation.¹⁴ Young authors (ages 35 and below) and mid-career authors (ages 36–50) have remarkably similar patterns in the ages of those with whom they publish: The average co-author of scholars in these age groups is pretty much the scholar’s contemporary. That is not true for the (relatively small and elite) group of older co-authors (those ages 51+). Their co-authors tend to be much different in age—averaging nearly 15 years different. Nearly all the older authors in the sample co-authored with people in the other two age groups, not with their contemporaries. Thus while we observe partnerships among contemporaries until the latter part of a career, partnerships late in a career are disproportionately with younger people. Their co-authors are not, however, likely to be their very recent Ph.D. students:

Table 5.7 Absolute average age difference between authors of two-authored articles, top three general Economics Journals, 1963–2011, means, standard deviations and number of articles*

<i>Period</i>	<i>Age of Co-author</i>		
	≤35	36–50	51+
All 6 years	6.1 (0.69) [119]	6.1 (0.45) [139]	14.6 (1.42) [35]
Subperiods			
1963, 1973, 1983	5.6 (8.66) [45]	5.8 (4.20) [46]	20.4 (5.81) [5]
1993, 2003, 2011	6.4 (5.29) [74]	6.3 (5.85) [93]	13.6 (8.45) [30]

*Includes all full-length original articles, except Nobel and Presidential addresses. Age could not be found for three authors in 1963, one author in 1973

With an average age of these older scholars of 58, a mean absolute difference of 15 years suggests that they are typically co-authoring with their mid-career colleagues.

Why might the difference in the age structure of co-authoring relationships change with age? One likely explanation is suggested by the relative, albeit decreasing rarity of older authors' appearances in this group of elite publishers. With the majority of older economists having ceased publishing, or even trying to publish, the set of potential co-authors with whom a productive older scholar can choose to work necessarily consists mostly of younger scholars. The results in Table 5.7 are explicable by propinquity of interest and energy.¹⁵

Some direct evidence on this explanation is obtainable by dividing the sample into articles published before and after 1990, taking advantage of the rise in the prevalence of older authors. The statistics are shown in the bottom rows of Table 5.7. While the age differences between co-authors ages 35 or less, or 36–50, did not change significantly over time, older co-authors worked with others who were significantly closer to their age in the latter period than before 1990. This change is consistent with the increasing availability of publishing older authors, providing their peers with an easier search for co-authors who were contemporaries.

5.4.2 *The Stability of Co-authoring Patterns over the Life Cycle*

A related issue is how scholars vary their co-authoring patterns with age, and the extent to which the choice of individuals with whom to co-author persists over time. To examine the first question I use the data on the 79 distinguished labor economists that underlay the analyses in Sections 5.2 and 5.3. For each publication after an author's first I form the coefficient of variation of the number of authors up to and including that publication. To the extent that the number of authors exhibits some randomness across publications, the coefficient of variation will decrease over an author's career (as the author ages). Thus in the analysis here I exclude the first ten (alternatively the first 40) publications by each author. The mean coefficient of variation of the number of authors on their 41st and later articles is 0.40.

Table 5.8 shows estimates of regression equations describing the coefficient of variation of the number of co-authors on all articles beyond the tenth (40th). To account for possible changes in co-authoring behavior beyond those shown in Section 5.2, the estimates hold constant the indicators of the decade when the article was published. The results are remarkably insensitive to the choice of sample: Those in later birth cohorts (younger authors) are significantly less likely to vary the number of scholars with whom they co-author than are scholars who are born earlier (older authors).¹⁶ These two outcomes are quite strongly associated: Moving from birth year 1934–1967, the extremes in the sample of articles

Table 5.8 Regression estimates of relation of birth cohort to lifetime variation in co-authoring patterns (dep. var. is the coefficient of variation)*

<i>Articles no.</i>	<i>11+</i>		<i>41+</i>	
	<i>All years</i>	≥ 2000	<i>All years</i>	≥ 2000
Ind. Var.				
Birth year	-0.0035 (0.0009)	-0.0033 (0.0009)	-0.0033 (0.0014)	-0.0029 (0.0013)
No. of articles	3202	1604	1507	1081
No. of Authors	70	69	43	42
Adjusted R^2	0.158	0.198	0.152	0.156

*The equations in columns (1) and (3) include a vector of indicators of the decade in which the article was published, with the 1960s and 1970s as the excluded decades. The equations in columns (2) and (4) include an indicator for the 2010s. Standard errors are clustered on the authors

that are at least the 41st in an author's career, decreases the coefficient of variation by 1.8 standard deviations.

The co-authoring behavior of scholars from earlier cohorts is less stable than that of scholars born later, independent of any confounding factors such as the dates when they published. The difference is not due to greater experience (since I held the number of their publications constant), but perhaps arises from their learned ability to pick out co-authors when that is appropriate and to author alone when it is not, or perhaps to differences in preferences across birth cohorts.

5.4.3 *Age and the Identity of Co-authors*

While authors from older cohorts exhibit less stable co-authoring behavior, that fact says nothing about the identity of the scholars with whom they co-author. Their behavior could be less stable, but they could be choosing the same individual or set of scholars when they co-author. To examine their stability defined in terms of their choices of individuals rather than their number, I calculate for each article the cumulative number of different co-authors with whom the scholar has published and the cumulative total number of co-authors, and then define their ratio as the "novelty index" of co-authorship. The novelty index ranges from 0.21 to 1.00 over all the 2701 co-authored articles in the sample. Figure 5.3 presents a scatter of this index and birth year for the most recent publication by each of the 79 authors. There is absolutely no relationship between the two measures: The most recent article published by someone in a more recent cohort is no less likely to reflect repeated matches with particular co-authors than is one by a scholar born earlier.

Estimates of the relationship between the novelty index and the author's birth year are presented in column (1) of Table 5.9 using all 2701 observations; but unlike in the equation fitted to the scatter in Fig. 5.3, here I include a vector of indicators of the decade when the article was published. The results demonstrate that, once we use the cumulative history of all the co-authored articles in the sample, we observe that those in more recent cohorts are more likely to exhibit novelty in their choice of co-authors. The difficulty with this conclusion is that scholars from more recent cohorts (younger authors) have typically written fewer articles, and even fewer co-authored articles, than their senior colleagues. They can be viewed as being engaged in the early stages of a search process for co-authors. One's first co-authored paper is *ipso facto* written with new co-author(s), and to

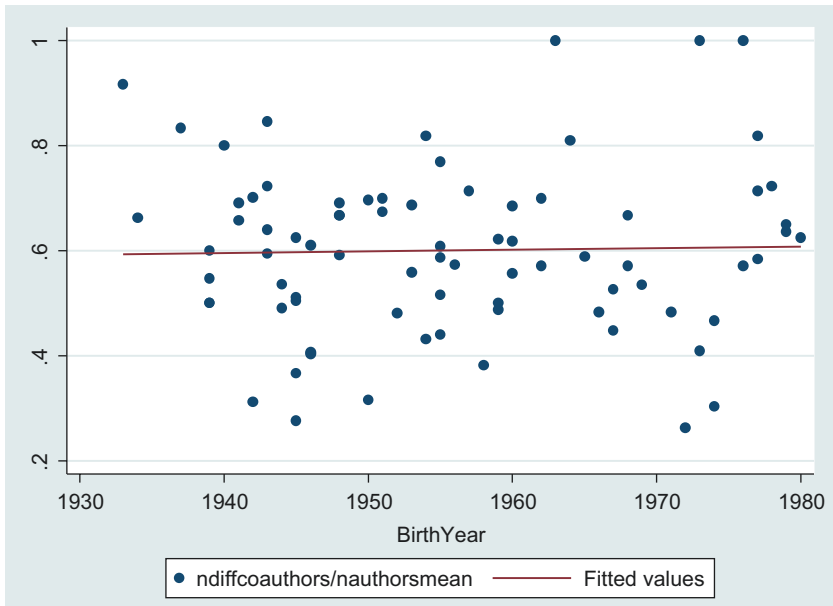


Fig. 5.3 Novelty of co-authors by birth year of author, $N = 79$

Table 5.9 Determinants of the novelty index of co-authors (2701 co-authored articles)*

<i>Ind. Var.</i>			
Birth year	0.0031 (0.0015)	–	–0.0008 (0.0014)
Article number	–	–0.0019 (0.0005)	–0.0020 (0.0005)
Adjusted R^2	0.234	0.295	0.296

*All specifications include a vector of indicators of the decade when the article was published, with the 1960s as the excluded decade. Standard errors are clustered on the authors

the extent that there is some randomness in the choice of co-authors, the next few are more likely to be written with new faces than are subsequent ones. Indeed, the estimates in column (2) of Table 5.9 suggest exactly this—each additional co-authored article reduces the share of an author’s new co-authors. Accounting for this fact in column (3), we see that there

is absolutely no relationship between birth year (age) and the novelty of co-authors once the authors' differential writing experience is accounted for (holding constant the date when the paper was published).

As an additional step in examining this issue, we can consider whether co-authoring partnerships are stable over a career. Restricting the sample to the 39 authors ages 60+ in 2014 (to allow sufficient time to observe repeated matches), only 36 of the 274 unique co-authorship matches into which these authors entered before age 41 were repeated after age 50.¹⁷ Matching with co-authors does not appear very persistent in this sample—most economists do not “mate” for (their professional) life. Rather, co-authoring in this elite group seems driven by the desire to find the best person or people to work with on specific research questions.

5.5 AGING FEMALE CO-AUTHORS

Are women different from men in their co-authoring behavior, in terms of the likelihood of co-authoring as they age and in the relationship between age and the number of co-authors? Previous evidence (McDowell et al. 2006) suggests that gender differences in the propensity to co-author in economics do exist, and Abrevaya and Hamermesh (2012) demonstrate the existence of gender-matching among co-authors. Re-estimates of the models in Section 5.2, however, suggest no difference between men and women in the relationship among age, cohort and time trends in this elite sample (although the paucity of women, 12 of 79 authors, and of their articles, 412 of 3968, sharply reduces the precision of the estimated impact of age for women compared to that for men). We cannot reject the hypothesis that pooled results presented in Table 5.5 describe men's and women's behavior equally well. Female authors are no different from their male counterparts of the same age (cohort) in reflecting the trend toward co-authorship that has characterized published research in economics.

Although the number of authors by age and time period appears independent of gender, perhaps female scholars, whose search for co-authoring partners may differ from that of male scholars, choose their co-authors differently as they age. One possibility is that limitations on search may lead them to “settle down” more than men once they have found co-authors to work with. To examine this possibility, the left-hand side of Table 5.10 presents descriptive statistics on co-authoring behavior by gender, including the number of co-authors and the number of different co-authors. Given the increase in women's participation in the profession, it is unsurprising

that the women in the sample are younger, have published fewer papers and have fewer co-authors. What is remarkable is that the novelty index is nearly identical for men and women (0.55 and 0.56).¹⁸ Despite the differences in age of men and women in the sample, novelty in co-authorship is the same for both.

Generalizing from these results may be difficult because five of the twelve women in the sample repeatedly co-author with their spouse/partner, who in some cases is also in the sample. Less important, given the large number of men in the sample, five of the men repeatedly co-author with their spouse/partner. To remove the possible “contamination” of inferences about the search for co-authoring partners by the (previously successful) search for life partners, I delete these ten individuals from the sample. The right-hand side of Table 5.10 presents the descriptive statistics for this reduced sample. The remaining women are younger than those who have been deleted (and have published less and have fewer co-authors); but the results on search for co-authors remain essentially unchanged, with the novelty index rising very slightly to 0.56 and 0.58 for men and women, respectively.

The sample of articles published each decade in the top three general journals that underlay Tables 5.1 and 5.2 allows examining whether the general result in Section IV.A., that people choose co-authors of similar ages, differs by gender among authors age 50 or less. (None of the co-authored articles in that sample includes women over age 50, so that I

Table 5.10 Co-author search and gender, descriptive statistics (means and standard deviations)

	<i>All</i>		<i>Non-partnered</i>	
	<i>Males</i>	<i>Females</i>	<i>Males</i>	<i>Females</i>
Birth year	1955 (13.99)	1960 (10.56)	1955 (13.48)	1964 (9.48)
No. of articles	53.13 (37.16)	25.43 (20.28)	34.33 (37.94)	52.98 (11.67)
No. of co-authors	54.34 (43.98)	37.17 (26.38)	54.05 (44.68)	27.29 (16.49)
No. of different co-authors	29.69 (21.56)	20.92 (17.96)	30.02 (21.08)	15.71 (8.42)
No. of authors	67	12	62	7
No. of co-authored articles	2399	302	2208	125

cannot examine this issue for scholars over age 50.) The scarcity of even middle-aged female authors might suggest that they are forced to seek out much younger scholars if they wish to collaborate. Comparing authors who are age 35 or less to those who are age 36–50, the average age difference between male authors in the younger group is six years, while that between female authors is five years. The difference between male authors in the older age group is also six years, while female authors age 36–50 write with people who differ in age from them by seven years. The double-difference of two years in age of co-authors by gender is consistent with the need for (the relatively few) middle-aged female co-authors to spread their nets more widely as they age (although the relatively small number of female authors means that the double-difference is not statistically significant).

5.6 OLDER AND YOUNGER CO-AUTHORS: COMPARISONS AND ETIQUETTE

5.6.1 *Comparing Achievements across Cohorts*

Do authors in different cohorts differ in productivity? The difficulty in answering that question is, of course, how one defines productivity. Here I answer this question only very partially, defining productivity as the number of full-time-equivalent journal articles written over a career. Implicitly I am dividing a paper's quality by N , where N is the number of co-authors listed on the paper. I am also ignoring differences in quality, as measured by scholarly impact, that may be related to the joint variation of number of authors and cohort.

Taking this admittedly partial approach, we can at least examine how trends in co-authorship and differences in behavior by cohort affect inter-cohort comparisons of output (defined here only by quantity). To minimize differences in input quality, I use the sample of labor economists, and I restrict the sample still further to those members who are also Fellows of the Econometric Society and are thus the more successful scholars in this already highly selective sample.

The first two columns of Table 5.11 describe the publishing behavior before age 60 of Fellows in the birth cohorts after 1954 and before 1955. The variables described in the first two rows are obvious and show that the Fellows in the earlier cohort were elected at later ages on average. The number of articles written is almost identical across the two cohorts, but members of the more recent cohort have had more co-authors. The table

Table 5.11 Publication counts and “full-time” equivalent publications, econometric society fellows—means, standard deviations and ranges

	<i>Publications before age</i>			
	60		50	
Sample:	All fellows		Became fellow before age 50	
Birth year:	>1954	<1955	>1964	<1965
Age when elected	39.50 (5.53) [33, 53]	44.78 (7.49) [33, 60]	40.33 (5.01) [33, 47]	40.33 (5.65) [30, 49]
Age when published	40.27 (7.51) [21, 57]	44.15 (8.94) [23, 59]	37.53 (5.71) [26, 49]	38.92 (6.29) [21, 49]
Average article no.	34.02 (23.39)	35.67 (25.77)	33.03 (26.70)	26.00 (17.40)
FTE/Article	0.490 (0.106)	0.651 (0.136)	0.487 (0.114)	0.628 (0.157)
No. of authors	14	23	6	24
No. of articles	780	1323	264	1050

then shows the ratio of FTE to total articles, calculated as the number of articles divided by the number of authors. Unsurprisingly given the results in Section II, this ratio is higher among members of the earlier cohort.

If the overall quality of research completed by members of these cohorts of very successful economists has not changed across cohorts (or at least not changed relative to research in the profession as a whole); and if one viewed the appropriate divisor by which to apportion credit for co-authored articles as D^*_{early} when the earlier cohort was being considered for promotion/appointment, then the appropriate divisor for assigning credit among authors in more recent cohorts should be higher. With the same inherent quality, today’s top scholars are publishing more papers per year than their top predecessors. Indeed, given the change in FTE/article shown in Table 5.11, one might conjecture that the appropriate divisor today is $D^*_{\text{recent}} = 1.33 \cdot D^*_{\text{early}}$ (i.e., $1.33 = 0.651/0.490$), thus accounting for the increasing propensity to co-author over time. Whatever divisor one uses to assign credit at a point in time, this evidence suggests that one should use a larger divisor when comparing publication lists of scholars in more recent cohorts to those of scholars in older cohorts.

One might argue, based on differences in the first two rows of the left-hand columns in Table 5.11, that the authors in these two birth cohorts in this sub-sample are not comparable in terms of ability. To account for

Table 5.12 Authors in the labor economists sample

Abowd, J	Katz, L	Welch, F
Abeler, J	Kennan, J	Wibrals, M
Abraham, K	Krueger, A	Willis, R
Acemoglu, D	Kube, S	
Altmann, S	Lang, K	
Altonji, J	Lange, F	
Angrist, J	Layard, R	
Ashenfelter, O	Lazear, E	
Autor, D	Lemieux, T	
Bailey, M	Lundberg, S	
Bandiera, O	MacLeod, W.B	
Barankay, I	Mas, A	
Bertrand, M	Meghir, C	
Blank, R	Michael, F	
Blau, F	Miller, A	
Blundell, R	Moffitt, R	
Borjas, G	Moretti, E	
Brown, C	Mortensen, D	
Burdett, K	Murnane, R	
Cain, G	Murphy, K.M	
Card, D	Neal, D	
Carrell, S	Neumark, D	
Chetty, R	Nickell, S	
Chiappori, P-A	Pencavel, J	
Chiswick, B	Pissarides, C	
Currie, J	Pollak, R	
Ehrenberg, R	Prendergast, C	
Farber, H	Rasul, I	
Freeman, R	Rosenzweig, M	
Goldin, C	Shaw, K	
Gronau, R	Shimer, R	
Hall, R	Smith, James	
Haltiwanger, J	Solon, G	
Hamermesh, D	Stafford, F	
Heckman, J	Taber, C	
Hershbein, B	Todd, P	
Hoekstra, M	Van Reenen, J	
Kahn, L	Weiss, Y	

this possibility, I further restrict the sample to authors who were elected Fellows before age 50 and consider only publications before that age in both cohorts.¹⁹ The right-hand columns of Table 5.11 show the results for this even more restricted sub-sample. Members of these cohorts look remarkably similar in terms of the ages at which they were elected Fellows and the ages at which their average publication in print before age 50 was produced. Scholars in the more recent cohort published many more articles before this age, but they also worked with more co-authors. The FTE/article is much lower than that of the earlier cohort. Indeed, the numbers of FTE articles are almost identical for the two cohorts, 15.5 in the more recent cohort and 15.4 in the earlier cohort. The ratios hardly change from their values in the first two columns, suggesting that this further attempt to compare scholars of identical ability does not alter the conclusion that today's divisor should be well above what it had been.

5.6.2 *Co-authoring Etiquette for Older Economists*

In economics publishing, the implicit assumption is that authors' names will be listed in alphabetical order (Engers et al. 1999), although there are a few exceptions loosely related to stature and contribution (van Praag and van Praag 2008). In the sciences, with nearly all published papers stemming from research grants to a principal investigator, that person is customarily listed as the last author (see, e.g., Nagaoka and Owan 2014). The difficulty in economics is that very junior authors, especially current or recent Ph.D. students who co-author with an established scholar, are assumed by many or even most readers to have either been glorified research assistants or to have executed a project on which the original idea was suggested by the senior author. As such, even if they contributed equally or more than equally, they typically receive less credit than the senior author in the eyes of neutral observers.

What can be done about this difficulty, one which is of growing importance as the profession allows more joint work, even with a doctoral supervisor, to be part of a Ph.D. dissertation? One solution might be for junior people to avoid co-authorship with their seniors, at least beyond the Ph.D. dissertation. This policy, however, restricts scholarly inquiry and will in the end reduce the overall quality of research.

Given the evidence above that older economists still tend to co-author with scholars who are very much their juniors, their choices about the ordering of names on such papers are important. A recent negative example

arose when a Ph.D. student (W) asked me to read a draft paper on which the authors were listed in the order M-B-W, where M is a very senior economist. I told him that this ordering of authors' names guaranteed that readers will assume that B, also a junior person, and he were M's assistants, and that he will receive very little credit from the profession for this work. Of course, M may write letters to W's potential employers delineating W's tremendous contributions to the project, but those letters will wrongly or rightly be viewed as cheap talk.

An alternative policy is to place the senior author's name last regardless of the relative contributions of the authors. My policy in the past decade has been to do that on the first paper I write with much more junior people, then to rotate the ordering alphabetically on subsequent papers. Thus my first paper with K and L was L-K-H, the next K-L-H and the most recent is H-K-L. I do not know if this solves the potential excess attribution to the senior co-author, but it may go partway toward a solution. Beyond that, it is not clear what can be done to signal that each co-author made a substantial original contribution to the project.

In economics, unlike in some of the physical sciences, there are no formal guidelines about who should be included as a co-author. Of course, if the profession gives full credit to each co-author, there is no reputational cost to including another person among the co-authors. Even if credit is divided by the number of co-authors, however, there is little cost to a very senior author of adding another co-author, since the reputational and monetary gains that any credit for the research will generate for the senior author are minimal or even zero.

Twice in the past decade an additional junior co-author whose contribution I would rate as below 5 percent of the project has been included on papers I have published. While the cost seemed small or zero to me at the time, in retrospect I view having included these co-authors as a mistake. First, and less important, in both cases there were other co-authors, each very junior. If credit is assigned by dividing by any number greater than one, including this nearly superfluous co-author harmed the productive junior co-author(s). Second, the nearly superfluous co-author whose reputation may be enhanced by inclusion in the list of authors will eventually demonstrate his/her lack of research expertise and be exposed as having done very little on the project. (Of course, with a sufficiently high rate of time preference, this consideration may be irrelevant for that junior person.) Third, and most important, including this person as a co-author is just wrong.

5.7 IMPLICATIONS AND SUMMING UP

The economics profession is aging. Using a large data set on lifetimes of publishing a number of distinguished scholars, I have shown that this fact and differences in research habits across cohorts of scholars can explain only a small part of the simultaneous trend toward more co- and multi-authorships of scholarly articles in the field. While scholars' choices of research methods as they age appear to become more eclectic—they exhibit more variation in the number of, if any, co-authors—they are no more likely than their younger peers to choose to work with different sets of co-authors on successive publications.

Working with other scholars is basically a search process—involving both personal preferences and potential production complementarities. Nearly all the findings here are consistent with the implications of search theory. In particular, the increasing positive assortative matching of older co-authors over time, and the changing interaction of gender and age in co-authoring behavior, are explicable by the increasing percentages of older scholars and women among those publishing articles in economics.

All the empirical results in this study are based on elite samples, in one case of individual scholars who have achieved substantial distinction over their careers, in the other of articles published in the three leading general journals in the field. Obviously these are not random samples of journals or scholars; but these authors and published works are the leaders in the field, reflecting the research that generally receives the most attention from other scholars. Moreover, given the general decline in publication rates with age, which is especially sharp for those who are relatively less productive early in their careers (Oster and Hamermesh 1998), if anything our results understate the effect of age on co-authorship and productivity. For those reasons, while not necessarily representative of the co-authoring behavior of all economists or of the content of all economic research, the results here indicate what is occurring at what is arguably the forefront of the economics literature.

As today's earlier birth cohorts are replaced by scholars from later cohorts who have developed somewhat different research habits, the results suggest that the trend toward increasing co- and multi-authorship will continue. To the extent that these collaborations enhance scholarly productivity, the disappearance of more senior scholars whose habits do not lead them toward collaboration can be viewed as beneficial. The central question for considering the structure of scholarly inquiry, however, is

whether the marginal scholarly collaboration is truly productivity enhancing, or, if instead of collaborating, the same scholars would contribute more by working on their own.

NOTES

1. Restricting the “sample” to refereed papers hardly changes the conclusion.
2. Three of the sample members (all English, and all currently over age 60) do not have a doctorate. To retain them in all the empirical work, I imputed their Ph.D. age as 28, the mean in the rest of the sample.
3. Among those ages 60+ in the sample, the average fraction of sole-authored papers was 0.41, while the average number of authors was 1.83. But the ranges were 0.12 to 0.83, and 1.17 to 2.55. Similar heterogeneity exists among authors in the later cohorts, although that is partly due to the much smaller samples of articles for which they have been responsible. This generates the heteroscedasticity shown in the figures.
4. I also use “calendar age” rather than “Ph.D. age” because of the three previously mentioned imputations of the latter and because 2 percent of the articles in the sample were published when or before the degree was received. None of the results discussed here changes qualitatively if we make this substitution.
5. If we do not cluster, the estimated standard errors in these equations are typically around 40 percent of those shown in the table. If we exclude the author who, with 184 articles, is a very extreme outlier (the second-most published author has 125 publications), the absolute values of the parameters shown here increase slightly.
6. The coefficients on the decadal indicators mirror the differences in co-authorship rates by decade shown in Table 4. The vector as a whole is statistically significant and remains so even if we add a time trend to the specification.
7. Excluding the 4 percent of articles published when a scholar was over age 65 (and thus probably excluding disproportionately articles that were not refereed), the impact of age in the probit in (1a) falls to -0.0050 (s.e. = 0.0020). Going further and excluding the 11 percent of articles published after the authors were age 60 reduces the estimated impact to -0.0043 (s.e. = 0.0020). Similar

small decreases in the estimated impact of Birth Year occur in re-estimates of (1b) and in the impacts in the ordered probits on the number of authors. The changes in all cases are thus minor and do not alter the general conclusions.

8. The estimates of the coefficients in the ordered probits describing the number of authors show a qualitatively similar set of results. The analogous estimates of the ordered probit coefficients are 0.0372 and 0.0324.
9. The results and comparisons are nearly identical if we exclude the three authors whose Ph.D. year was assigned and their 269 published articles from the sample.
10. Only 0.4 percent of the articles appeared after a five-year or longer hiatus. None of the results discussed in this section is at all sensitive to the inclusion of these few observations in the estimation.
11. The equations were all re-estimated using a negative binomial estimator. While the dependent variable is significantly over-dispersed, so that this estimator is more appropriate than the Poisson estimator, the coefficient estimates are hardly affected. I thus present the more easily interpreted Poisson estimates.
12. If we exclude the six authors whose most recent publication appeared before 2010, which deletes 258 articles from the sample, the results shown in the table hardly change.
13. Freeman and Huang (2014) examine another demographic characteristic—ethnicity—in the process of matching of co-authors.
14. There are too few multi-authored articles involving older authors to make any statistical analysis worthwhile.
15. They seem consistent with the results of Fafchamps et al. (2010) showing the role of nearness within a social network on the choice of co-authors.
16. This result is not due to the fact that older authors who publish in a given year have published more papers up to that date: In an expanded specification that includes the number of articles each author has produced to date, the estimated absolute impact of birth year on the coefficient of variation of the number of authors declines but it remains significantly negative.
17. As an aside on this comparison, of the 2237 unique co-author matches in the sample, only 10 percent represent matches that persisted for more than five years (i.e., the authors have published papers with each other that are at least five years apart). Only

- 1 percent of co-author pairs published together over a 20+ year period, with the maximum interval in the sample being 28 years.
18. Regressions that hold constant the author's birth year, the article number and the date of publication of the article suggest that the absence of gender differences is not due to correlations with other covariates.
 19. This restriction retains all the sample members who had achieved the additional distinctions mentioned in Section II.

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