

Rise of Multi-authored Papers in Economics: Demise of the 'Lone Star' and Why?

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Abstract

This paper builds on previous work by reviewing the key literature relating to the rise in co-authorship in economics and by presenting further new evidence on several features of co-authorship in articles in economic journals. The empirical analysis draws on around 175,000 articles in the top 255 journals, over the period 1996 to 2014. The rises in quarto-plus and cross-country co-authored papers are striking, as are the differences in citations per article and citations per author. There is evidence of an alphabetical ordering of authors as the standard in co-authored papers in top journals with no downward trend evident over time. A correlation between co-authorship and career stage is observed with young authors publishing significantly more solo-authored articles.

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1. Introduction

Much has been written about the phenomenon of co-authorship in economics in the last thirty years, as prior to this sole-authored papers were the main output by far in economics journals.¹ More recently, Henriksen [2016] documented the rise in co-authorship in the social sciences in general over the last 30 years, using a very comprehensive data set. Rath and Wohlrabe [2016]), building on Nowell and Grijalva [2011], and also using very large data sets, established that the upward trend is visible across all sub-disciplines in economics and across different quality levels of journals.

The purpose of this paper is to develop on the work above in three ways. First, to review in some detail the economics literature relating to this phenomenon. Second, we outline new large and different data sets used in this paper to explore co-authorship in economics. We focus on two specific sets of economic research journals: a broad set including the top 255 and a top journal sample including the 20 best ranked journals for the period 1996 to 2014. Previous work on co-authorship in economics, bar Rath and Wohlrabe [2016] and Sommer and Wohlrabe [2017], is limited to small subsamples of economic research. While these two recent papers use RePEc as their source of data, this paper uses Scopus and additional sources, thereby providing different and supporting new evidence for their work.² Third, we trace several aspects of co-authorship including overall shares, citations received and given, pages, career age, and the listing of authors for each author category, ranging from one to four-plus authors, separately. We provide these statistics by journal sample and over time. This is followed by a brief analysis of how the new data inform the debate in the literature on the causes for the rise in co-authorship.

The remainder of this paper is organised as follows. Section 2 reviews the key literature relating to co-authorship in economics. Section 3 provides information on the data used. The empirical findings are discussed in Section 4 and Section 5 concludes the paper.

2. Key literature

There is an extensive economics literature on the phenomenon of the rise in co-authorship in journal articles. The purpose of this section is to review this literature, and to demonstrate how this provided the context for the later data collection and empirical analysis.

The earliest substantive paper perhaps to look at the phenomenon of the rise in co-authorship in the economics literature was McDowell and Michael [1983], but using just ten journals in their sample. Barnett et al. [1988] widened the discussion considerably, but using an even narrower data set, namely the AER alone. Their starting point is what they term the 'division of labour' hypothesis, very similar to the specialisation focus of

¹See for example McDowell and Michael [1983], Barnett et al. [1988], Hudson [1996], Wuchty et al. [2007], and Card and DellaVigna [2013].

²The main reason for this is that the Scopus data allowed for exploration of other work (see Kuld [2017]) not possible using the RePEc data.

the earlier McDowell and Michael [1983] paper and the later paper of Jones [2009], and put succinctly as follows.

Individuals engaged in economic research have found it increasingly possible (and, indeed, necessary) to specialize in more narrowly defined areas within the profession. As such specialization has proceeded, it has become increasingly necessary to combine the skills of two or more scholars in the conduct of research projects. For example, one who is highly skilled in the testing of hypotheses may find it attractive to collaborate with one skilled in generating hypotheses. Both, in turn, may find it attractive to combine their efforts with one skilled in collecting and organizing the data required to implement empirical tests. Thus, as specialization proceeds, we should expect to observe, over time, an increase in the incidence of co-authorship. (Barnett et al. [1988], p. 539)

Neither of these papers though looked at the breakdown of co-authorship between different numbers of co-authors. Besides they used narrow data sets.

Another argument is the increasing emphasis on publication in refereed journals as a criterion for appointment and promotion. The days of books or chapters in books, or policy reports counting towards a person's research record have been it appears in decline since the 1970s and have been largely replaced by verifiable 'scientifically-ranked' journals and citation records. Barnett et al. [1988] argue that this allows less time to assist colleagues, the 'reward' of an acknowledgement or 'thank you' being replaced with the offer of co-authorship to elicit such assistance. This is their opportunity cost of time hypothesis.³

Another hypothesis relates to 'risk-aversion', which says it is better to spread your risks by submitting say four quarto-authored papers than one solo-authored paper. If the emphasis on journal article publication has increased, such considerations would have assumed greater importance over time. Barnett et al. [1988] argue that the variance and hence randomness of the process for assessing articles submitted has increased and hence so has the incentive to diversify through co-authorship. The key argument for this assertion is the huge increase in the number of journals and hence the difficulty of finding suitable editors and referees.⁴

Sauer [1988] tested the hypothesis of a higher return on co-authored papers but found that an individual's return from a co-authored paper with n authors is approximately $1/n$ times that of a single-authored paper.⁵

³It is not clear though that if books and reports no longer count that the total demands on research time, and hence the opportunity cost of time, should have risen. Books and reports in many cases would have taken up a huge amount of research time, time now 'free' for journal article research and assistance to colleagues.

⁴However, while it is true that there has been a huge increase in the number of journals and articles submitted, there has also been a large increase in the number of economists upon which to draw on for editorial and refereeing purposes (see Osterloh and Frey [2014]), implying no increase in work-load per referee and editor.

⁵One wonders would that be the case today. From anecdotal evidence it appears that the return on a

Medoff [2003] examines the widely held belief that researchers who collaborate produce higher quality research than those who are sole-authors. Like for the other articles he used a small number of journals, eight in this case. The empirical results he argues show that, controlling for article length, journal and author quality, and subject area, collaboration does not result in significantly higher quality research (as measured by the number of citations an article receives) in economics. The key question though is it citations per article or citations per author which matters. And if there are more citations for co-authored articles, which there are, does the increase in citations compensate for the fact that it took three to four authors, rather than one, to effect this increase?

Rosenblat and Mobius [2004] argue that advances in communication and transportation technologies have the potential to bring people closer together and create a "global village" and hence more collaborative work. They develop a model which they test by looking at the evolution of academic co-authoring between 1969 and 1999. Several new technologies decreased the cost of communication substantially starting around 1980. First fax technology became ubiquitous in the 1980s; second, emailing and file transfer through FTP was common by the beginning of the 1990s; third and perhaps most importantly, the rise of the Internet in the 1990s made it dramatically easier to publish and search for working papers.⁶ Moreover, deregulation of the US airline and telephone industries in the 1980s drastically decreased the cost of traveling and making long distance telephone calls. Their data set contains 8,838 authors of whom 6,201 authors published at least one co-authored papers. It is possible though that this simply altered the nature of the co-authorship rather than the quantities of articles co-authored. A wider network from which to choose should change the pattern of co-authorship but it does not imply without further argument that the incidence of co-authorship increases.⁷

Jones [2009] took up the division of labour argument also, but applied in this case to scientists and engineers. His starting point is that while physical stocks can be

co-authored paper today might be considerably more than $1/n$ times that of a solo-authored paper, which in itself would be a very strong argument for the rise of co-authorship. It is likely that the more cross-country the co-authorship the more likely is the chance that there is no discounting of multi-authored papers (see later).

⁶Agrawal and Goldfarb [2008] examined the effect of a decrease in collaboration costs resulting from the adoption of Bitnet (an early version of the Internet) on university research collaboration in engineering, their interest being the broader question of how changes in collaboration costs may affect the structure of knowledge production. They examined 270 universities that published in seven top electrical engineering journals from 1981 to 1991 and found that a Bitnet connection did seem to facilitate a general increase in multi-institutional collaboration (by 40 percent, on average). Catalini et al. [2016] built on the explanation that links the increase in co-authorship to the drastic reduction in communication costs brought by the internet: as coordination and communication costs go down, scientists are able to sustain collaboration over distance in a more efficient way. In this paper, they test a complementary hypothesis: that the increase in distant collaboration may also be the result of the dramatic reduction in air travel costs that took place within the United States over the last 30 years.

⁷The focus of Fafchamps et al. [2010] was linking the extent of co-authorship to networks. The stronger the networks the greater the degree of co-authorship. They also note though that networks maybe are not as important in determining co-authorship given the greatly increased access to the web. They also address a potential problem, namely the time between when collaboration commenced and when it is noted, namely in a publications.

transferred easily, as property rights, from one agent to another, human capital, by contrast, is not transferred easily. The vessel of human capital-the individual-is born with little knowledge and absorbs information at a limited rate, so that training occupies a significant portion of the life cycle. Moreover, if innovation increases the stock of knowledge, then the educational burden on successive cohorts of innovators may increase. Innovators might confront this difficulty through two basic channels. First, they may choose to learn more. Second, they might compensate by choosing narrower expertise. Choosing to learn more will leave less time in the life cycle for innovation. Narrowing expertise, meanwhile, can reduce individual capabilities and force innovators to work in teams, namely be involved eventually in co-authored patents or in the case of economics co-authored journal articles. His empirical work looks at three issues resulting from what he calls the 'burden of knowledge and death of Renaissance man', namely team size, date of first innovation and specialisation.

Hamermesh [2013] in a broad overview mused about possible broad explanations for the rise of co-authorship. He also examines the issue of multiple authors, one of the first to do so in economics and argues that co-authorship can be more fun, but why should this have increased over time,⁸ and he also refers to the increased opportunity cost of time in the 'rat race' to publish more and more journal articles. In this situation as noted by others already, the 'price' of getting feedback on your work might be the offer of co-authorship.

Ossenblok et al. [2014] analyse co-authorship patterns in the social sciences and humanities in for the period 2000 to 2010. The basis for the analysis is the Flemish Academic Bibliographic Database for the Social Sciences and Humanities (VABB-SHW). Standing out in this case study is the fact that the Flemish research-funding system actively encourages co-authorship through its use of whole counts, that is giving- each institution full credit for an article that bears its name and address. This is opposed to systems that use fractional counts, that is counting an article as a single unit and fractionalising the publication credit. They do not indicate though how this might have changed in Flanders or indeed anywhere else, but yet it could be a vital factor, not only in research funding but in the global ranking of universities and hence for hiring and promotion. If by adding another person benefits him/her and takes nothing away from you, it is clear that there will be a huge incentive to be involved with co-authored papers, the more authors the better.

Across the social sciences, Henriksen [2016] examines the rise in co-authorship over a 34-year period. The paper investigates the development in co-authorship in different research fields and discusses how the methodological differences in these research fields together with changes in academia affect the tendency to co-author articles. The study is based on bibliographic data on about 4.5 million peer-reviewed articles published in the period 1980-2013 and indexed in the 56 subject categories of the Web of Science's Social Science Citation Index. The results show a rise in the average number of authors, share of co-authored and international co-authored articles in the majority of the subject

⁸Önder and Schweitzer [2016] also examine trends in co-authorship, highlighting the rise in papers with more than two authors, applied to PhD graduates from German-speaking countries.

categories. However, the results also show that there are great disciplinary differences in the extent of the rises in co-authorship. The subject categories with a greater share of international co-authored articles have generally experienced an increase in co-authorship, but increasing international collaboration is not the only factor influencing the rise in co-authorship. Hence, the most substantial rises have occurred in subject categories, where the research often is based on the use of experiments, large data set, statistical methods and/or team production models. This then provides more descriptive evidence for the Barnett et al. [1988] and Jones [2009] hypotheses.

Two recent papers provide an extensive data analysis for co-authorship in economics. In the first of these focusing on 28,000 articles by American economists between 1985 and 2004, Nowell and Grijalva [2011] study co-authorship by economic sub-field (JEL-Code) and journal category. The key findings are, first, that quantitative papers, which the authors assume to be technically more demanding, are more likely to be co-authored, a fact that the authors attribute to specialisation effects (see Barnett et al. [1988]). Second, higher ranked journals tend to have more co-authors. Third, co-authorship increases over time and differs between sub-fields with the extremes being economic history at the lower and financial and agricultural economics at the higher end.

Rath and Wohlrabe [2016] expand on this using an international and a much larger data set based on over 700,000 articles in 1,615 economics journals in RePEc. Their findings mainly confirm the results obtained by Nowell and Grijalva [2011] for this wider sample. In addition, the authors show, first, the overall shares of articles by number of authors over time. Second, the average number of authors in articles that include an author without a previous registered publication on RePEc is found to be similar to the overall number and follow the general trend to increased co-authorship.

Four main strands then emanate from this literature with regard to the causes of the rise in co-authorship in economics. First is the increasing specialisation and division of labour hypothesis addressed in several papers. Second is the role of decreased communication and travel costs associated with increased co-authorship, especially across countries. This implies that the ease of co-authorship has increased. Third, the incentives set by the research community have changed. On the one hand, this leads to an increased opportunity cost of time which in turn leads to the addition of more authors than was previously the case, either because it forced researchers to be more efficient through co-authorship or because it reduced the willingness for collaboration or help without full recognition as co-author. On the other hand, co-authorship would be a response to avoid the risk of no publication. This depends though on how multiple authorship is discounted by hiring and funding agencies.

3. Data sources

The research objective was to generate data, the analysis of which might inform the above debate, using a large number of economics journals and differentiated by quality as measured by impact factor. To identify such economic research publications, all journals ranked in Kalaitzidakis et al. [2011] are used. The over two hundred journals in

this list were supplemented with a number of other economic journals, if highly ranked in Ideas RePEc (ideas.repec.org). From this process we ended up with 255 of the most influential journals in economics by citations received.

In total, 174,266 research articles were published in these journals between 1996 and 2014 and listed on Scopus (scopus.com). All of these are included in the data analysis. For each article, Scopus includes information on the authors, journal title, number of pages, year and the number of citations received.⁹ These data then allowed us to examine co-authorship in its various dimensions, in particular co-authorship involving two, three and four plus individuals and the trends in each by different rankings of journals, citations per paper and per author, and average page length.

In addition, these data are used to identify the 1,000 most cited economists, a small subgroup of the total.¹⁰ Using on-line CV data for each, a career profile was then constructed for all, but these data are used in this paper only to a very limited extent, namely to examine the different career-age profiles with regard to preferences/outcomes in relation to different types of authorship (solo, duo, treble or quarto-plus). To do this, we looked at the 133 top economists who completed their PhDs 1996 and 1999, inclusive, and then plotted the trend in their publications from year of graduation by type of solo and co-authorship.

To add data on international collaborations, a search on Web of Science (webofknowledge.com) for economics articles with author affiliations in the US and other specific countries was carried out. We use this additional source to study the rise of increased cross-country co-authorship, potentially due to technological change and cheaper travel, as it has been posited as seen earlier as a reason for the steep rise in co-authorship.

4. Empirical analysis

4.1. Trends in charts

Figure 1a provides the picture of the overall trends in co-authorship in economics. Ninety-five per cent confidence intervals are provided for each year, relating to yearly means. As recently as 1996 solo-authored papers accounted for fifty per cent of all articles published in our sample, with this number dropping to just over twenty-five per cent in 2014. While duo-authored papers share of the total remained steady, the huge pickup was in trio and quarto-plus authored papers, particularly the latter. By 2014 quarto-plus authored papers accounted for around eight per cent of the total, and trio authored papers for around twenty-five per cent of the total, more than double that of less than fifteen years earlier. This is a remarkable turnaround in a very short period. The picture is replicated whether the data relate to all journals (top 255, Figure 1a) or the top 20 journals (Figure 1b), but different trends are evident. The rise of trio and quarto-authorship is particularly marked in the top 20 journals, with just over twenty

⁹Other data bases include Google Scholar, RePEc and EconLit. Scopus (scopus.com) has full coverage of the selected journals from 1996.

¹⁰The primary purpose of our data-collection exercise was to obtain information on the career paths the most published economists in of the last twenty years (see Kuld [2017]).

per cent now solo authored, with the number of trio and duo authored papers exceeding the total of single authored papers by a wide margin.¹¹ If present trends continue the number of quarto-plus authored papers could soon exceed the number of single authored papers.¹²

Turning now to the trends in co-authorship by country, we look at the pattern examining co-authorship between US researchers and economists from other countries.¹³ This focus on American collaborations is motivated by the ongoing dominance of US universities in journal article output in economics. Figure 2 plots the percentage of each category of cross-country co-authored papers as a percentage of the total paper output of the two relevant countries combined. As such, this is a relative measure and hence a better indicator of trends.

Since 1990 there has been a huge rise in co-authorship across countries, especially between the US and the UK. The rises for the other country combinations though are large, especially as they are expressed in percentage terms. Of particular note is the rise in co-authored papers with China: their share expressed as a percentage of the total number of articles in both countries has risen from close to zero just fifteen years ago to almost four per cent in 2014. These trends may give us an insight again into the possible reasons for the rise in co-authorship to be looked at later. It is noteworthy though that the highest shares apply to US-UK and US-Canada articles, reflecting perhaps strong cultural connections, not least language. Still, the increases in US-China, US-Germany and US-France co-authored papers has been marked, with the gap between them and US-UK and US-Canada set to close in years to come perhaps.

Turning now to citations per article by co-authorship type, Figure 3a shows citations per article in the top 255 journals, *relative* to the yearly mean. It shows that citations per article are consistently highest for quarto-authored and lowest for single-authored articles. The picture with regard to the top 20 journals is similar but with differences (Figure 3b). As can be seen there is huge variability in the citations for quarto-authored papers (mainly due to the very small number of articles in the earlier years). Again, in almost all years their level is higher than those for trio and duo-authored papers, but with very wide confidence intervals evident at times. For every year citations are lowest for single-authored papers.

However, when citations per author are considered a very different picture emerges (Figure 4). As can be seen citations per article per author are much higher for single-authored papers and this is an alternative, arguably better, indicator of the contribution of an individual to the field. This is true no matter which category of journal is used. However, citation counts are no absolute indications of influence or even quality which makes such arithmetic difficult. The interesting question is how funding agencies and hiring/promotional bodies view co-authored versus single-authored papers.

¹¹Rath and Wohlrabe [2016] broke the 1,615 journals used into quartiles using RePEc impact factors and found that the rises in all quartiles were the same, with the average number of authors in the top three quartiles very similar. The top quartile though includes over 400 journals.

¹²It is reassuring that similar trends were found in Rath and Wohlrabe (2016), even though using very different data and categories of authors.

¹³It would be interesting to expand this work to other pairwise comparisons (see Henriksen [2016]).

Are journal articles getting longer and is there much variation by degree of co-authorship? Figure 5a illustrates that for the top 255 journals there was a large rise in the number of pages per article up to the early 2000s but large declines following this, with rises again in recent years. The pattern is very similar across all author types, with on balance no increase in the number of pages over the whole period regardless of author type. It is also noteworthy that the number of pages differs by just one to three pages across author types, differences which might be considered very small. This implies that the number of pages per author is much higher for solo-authored paper. The picture with regard to the top 20 journals is different in some respects (Figure 5b). Overall there have been increases in the number of pages regardless of author type.

A related issue is the number of cited references, the trends in which are outlined in Figure 6. There has been a large increase in the number of references, in a very short period, particularly in the trio and quarto-plus authored papers. For example, the number of references in the quarto-plus authored papers was around 23 with the number rising to over 40 by 2014. Similar increases are evident for the other categories in Figure 6, with the average number of references for solo authored papers rising from 22 to 35 in the same period. The observed differences in article length and references given are in all categories much smaller than the differences in citations received.¹⁴

Another issue related to the later discussion is the alphabetical ordering of author names on the articles by author type. Figure 7 shows that there is a high proportion of articles using alphabetical ordering of names on the papers, even if adjusted for random alphabetical ordering.¹⁵ The figure is around 60 per cent for duo and trio authored papers, but only around 40 per cent for quarto-plus authored papers. However, and of importance to the later argument, these percentages slightly increased over the period examined. The alphabetical ordering of names is particularly high in the top 20 journals, with no significant differences evident by number of authors (apart from one downward spike). This implies that the contribution of each author is *signalled* to be approximately equal which increases the costs of token adding of names. In addition, this makes it impossible to directly identify roles within the author team, for instance the lead author listed first or the group supervisor listed last.

One final chart constructed to throw light on the phenomenon of the rise in co-authorship relates to the career profile of 133 top economists who were awarded their PhD between 1996 and 1999, the data for which were discussed earlier. It is not clear though how representative this sample might be, but the trends are nonetheless instructive.¹⁶ Figure 8 plots the articles by number of authors for these top 133 economists in

¹⁴See Card and DellaVigna [2013] and Card and DellaVigna [2014], for discussions of trends in article length, but not from a co-authorship perspective).

¹⁵Ordering by contribution can lead to unintentional alphabetical listings. For instance, a random order is alphabetical in 50 percent of duo-authored articles. The share of non-alphabetical duo-authored papers is, therefore, taken out of half of the sample. Accordingly, trio-authored papers are related to five-sixths of the sample and quarto-authored papers to 23/24.

¹⁶Rath and Wohlrabe [2016] looked briefly at this issue, from a different perspective. They used the first journal article to examine whether or not the average number of papers by 'scientific rookies' is smaller than the overall average but find that this is not the case. The analysis in our paper differs by following authors over their career.

the years following their PhD graduation. For each year and team size, the number of publications is divided by the total number of authors published in top 20 journals in the same year and with the same number of co-authors.¹⁷ As can be seen in Figure 8, the share of solo-authored papers by these economists is highest and rises in the first five career years and thereafter declines steadily for the following ten years. In later years the shares of the categories converge which implies a publication pattern similar to the group of all top 20 journal authors.

4.2. Regressions: testing key trends

In this subsection, quasi-Poisson and logit regressions are used to build on the observed trends noted above. This allows to formally test the significance of observed differences while partly controlling for unobserved trends in economic publications using journal fixed effects. We estimate and show in Table A.1 the relation between co-authorship and key outcomes, namely citations received, references given and pages published.

$$\mathbb{E}(Y_i | \#A_i, T_i, J_i) = g^{-1}(\gamma_t T_i + \gamma_j J_i + f(\#A_i, J_i)) \quad (1)$$

Where, Y_i is either citations received, references given, pages published, or alphabetical order of article i . $\#A_i$ is the number of authors, and T_i and J_i are a dummies for publication year and the article's journal. g is the used link function, that is the natural logarithm for the quasi-Poisson regressions (columns (1) to (3)) and the logit function for the alphabetical listing in specification (4). f is a linear function of the number of authors interacted with a dummy to denote top journals.¹⁸ We estimate the effect of two or more, three or more, and four or more authors for top 20 and other journals. In this specification, we estimates, therefore, whether an additional author has a significant effect compared to articles with one author less (up to the forth co-author). We also estimate whether there is a significant difference between top journals and other journals for each author team size. For convenience, we also express all co-author categories as differences to single authorship in an alternative specification (Table A.2). The regressions are identical otherwise. All regressions include dummies for year and journal and robust standard errors clustered at the journal level.

Overall, co-authored articles are consistently longer and reference more articles than single-authored papers but the differences are small in size. The substantial increase in pages occurs with the addition of the first co-author. The estimated effect of this co-author is a six percent increase in pages (Table A.1, column (1)). The addition of further authors is associated with only a modest increase of around one percent, that is less than a half a page on average. The estimated effects on references given are similar but again smaller (column (2)). The estimated 62 percent increase in references overall from 1996 to 2014 is substantially larger than the differences between author categories.¹⁹ In

¹⁷The top 20 journals are picked as the reference group as said economists are highly cited. However, taking all journals does not alter the conclusion.

¹⁸ $f(\#A_i, J_i) = \beta_1 DuoPlus + \beta_2 DuoPlus + \beta_3 TreblePlus : Top20 + \beta_4 DuoPlus : Top20 + \beta_5 DuoPlus : Top20 + \beta_6 TreblePlus : Top20$

¹⁹The estimated percentage effect for $\gamma_{2017} = 0.485$ is calculated as $(e^{0.485} - 1) * 100 = 62.4$.

addition, the interaction of a linear time trend with the number of authors indicates a slight decrease in the effect of co-authorship on the number of pages and a slightly increased effect on references given (see Table A.3).

Duo, treble and quarto authored papers are associated with 30 to 90 percent more citations received than single-authored papers (Table A.1, column (3)). The effect of the first co-author is again larger than the effect of further co-authors. The estimated effect of co-authorship does not differ significantly between publications in top 20 journals and other publications.²⁰ Since we use dummies to account for differences between journal means, the estimates indicate a surprisingly strong variation by author number in the expected mean within a journal.

These findings confirm the positive relation between co-authorship and citations received which was observed by Sommer and Wohlrabe [2017] for the full sample of RePEc publications.²¹ We add that this relation holds within journals and for each additional co-author up to four.²²

In addition, we estimate the probability of an article to be sole, duo, treble, or quarto-plus authored based on publication year and journal. Arising from four logit regressions, odds ratios are constructed for the rise in articles with different number of authors and plotted for the publication year in Figure 9. Figure 9 again confirms and markedly so the very large rise noted earlier in the share of quarto-plus authored. For instance, the odds that a paper has four or more authors is 4.4 times as high in 2014 than 1996. The share of trio-authored papers also increased considerably with the odds that a 2014 article is trio-authored being 2.6 times as high as that in 1996. The share of duo-authored papers increased less (10 to 20 percent over the years) and a marked decline is observed in the share of solo authored papers where the odds that a 2014 publication is single-authored are only half the odds of a 1996 article to being single-authored.

4.3. Reflection on explanations

The empirical evidence above is used in this section to reflect on the explanatory hypotheses outlined in Section 2. First, the necessity and ease with which to specialise within a research team are discussed. Second, the role of decreasing communication costs is linked to the increase in international collaborations. Third, the pressure to

²⁰Table A.3 indicates that this correlation between co-authorship and citations received weakens over the years. However, this might be caused by the overall compression of citation counts.

²¹Sommer and Wohlrabe [2017] and Moosa [2017] examine the relation of co-authorship and citations received. Moosa [2017] studies the 300 most cited articles on RePEc and find no effect of co-authorship on citations received. Sommer and Wohlrabe [2017] repeat this exercise by varying the sample of articles by citations received and conclude that a negative effect of co-authorship is only visible for highly cited articles (though not significant). Taking the full sample of RePEc papers leads to a positive relation between co-authorship and citations received.

²²In addition, we confirm that this correlation holds throughout the distribution of citations received. We estimate the probability that an article has been co-authored based on the citations it received relative to the other articles published in the same year. Using such relative citation brackets, we see that the more citations it received the more likely an article is co-authored. This holds for two to four-plus authors and throughout the distribution of citations received up to the top percentile, that is the 95 most cited articles per year.

publish is discussed in the light of the surprisingly high incidence of solo-authorship among young researchers.

Specialisation in the context of co-authorship relates to the benefit of specialised roles within an author team. These should be higher the easier it is to divide research roles and the wider is the necessary research knowledge. For instance, Nowell and Grijalva [2011] observe more co-authorship in more quantitative sub-fields of economics. It may be easier to separate quantitative research - or research that contains a quantitative and a theoretical part - than a purely theoretical work. Or, the former may necessitate two or more specialists because a single researcher is less likely to possess all necessary knowledge as discussed earlier in relation to the work of Barnett et al. [1988], McDowell and Michael [1983] and Jones [2009].

Our empirical analysis though gives no strong evidence for this hypothesis. Comparing published research, we observe no increased return of co-authorship over time if measured by citations received or pages per article (see Figures 3, 4 and 5 and Table A.3). Only the increased share of co-authored publications itself might indicate a higher return to co-authorship. We also do not find a trend towards research teams in which team roles or contribution are signalled by the ordering of names. Figure 7 shows the high and unchanging incidence of the alphabetical listing of authors.

The Internet and cheap flights did lower the costs of communication and, subsequently, co-authorship between distant researchers. The evidence in relation to co-authorship across countries and in relation to the huge rise in the number of citations would tend to support the argument that technology and transport costs may have been key factors (see Figures 2 and 6). However, as stated above, while a wider network from which to choose should change the pattern of co-authorship, it does not necessarily increase the incidence of co-authorship. More importantly, technological progress simplifies the sharing of research with all, including spatially closer, colleagues. As noted above the ease of dividing research into separate tasks should increase the incidence of co-authorship.

If the pressure on economists for more articles has increased over time, researchers can respond by increased co-authorship. First, shared work should be less time consuming than solo-authoring if there are gains from the division of labour. Second, if co-authored papers are not discounted by the number of co-authors in the assessment, for instance during hire or promotion decisions, this would provide incentives to co-author (see the discussion of Ossenblok et al. [2014] above). In addition, co-authorship diversifies the risk of individual research projects failing. However, the high incidence of solo authored papers in the early career stage points towards the ambiguity of co-authorship in the hiring process (see Figure 8). Young economists might react to a perceived disadvantage of co-authorship. Sarsons [2017b] shows that in tenure decisions, women receive less credit for co-authored work than men. It is likely that young authors are equally perceived as not fully contributing to co-authored work and, therefore, choose to solo-author.²³ Again, other explanations such as a smaller network of potential co-authors are possible

²³In a follow-up version of this paper, Sarsons [2017a] finds no such discrimination in sociology, a discipline in which authors are listed according to contribution. Interestingly, sociology articles, though, have fewer authors on average (see Henriksen [2016]).

though.²⁴

5. Concluding comments

The dramatic rise in multi-authored papers in economics as outlined in Section is at the very minimum of interest to economists. Explaining these trends is a different matter. As always in economics, several different factors are at work simultaneously and despite claims to the contrary, holding for fixed effects and using other techniques, simply cannot overcome the reality that when variables are all moving together it is nigh impossible to separate the effects.

A related problem is that many of the key variables cannot be measured and hence have to be excluded from the formal regression analysis. This is particularly the case given the huge variety of factors posited for the trends in co-authorship in science over the last forty years.

We can show though the substantial trend to multi-authorship in economics, with top ranked journals leading the way but increasing throughout the economic literature. Conversely, we do not observe a trend towards vertically differentiated author teams that signal role or contribution by order of names. There is also no evidence for time trends in the observed differences in pages, references given, and citations received by number of authors. This observed unchanging but high correlation between the number of authors and citations received even within journals is difficult to explain.

We conclude by returning to the title of the paper, namely whether or not we are witnessing the demise of the 'lone star' in journal article publication in economics. It is true that solo-authored papers have declined quite dramatically as a proportion of the total, especially in the top 20 journals. However, over twenty per cent of all articles in top journals are still solo-authored and in many cases with citation counts as high as or higher than for papers with multiple authors. Besides, it is important to note the evidence for a large share of single-authored work among the most cited articles (see Sommer and Wohlrabe [2017] and Moosa [2017]) and by young top economists shown in this paper.

As such, we certainly have not yet witnessed the demise of the lone star, simply relative decline. However, if the trends in the last thirty years or so were to continue the demise of the lone star in economics would indeed become much closer, at least in the form of publication through journal articles.

What is needed more perhaps is more evidence on hiring, promotional and funding decisions with regard to solo versus multi-authored papers. The patchy evidence would seem to suggest that there is limited discounting of a published article by number of co-authors except perhaps for young or female authors (see above and Sarsons [2017b]). If this has further decreased over time then perhaps a key part of the explanation may

²⁴The focus of Fafchamps et al. [2010] was linking the extent of co-authorship to networks. The stronger the networks the greater the degree of co-authorship. They also note though that networks maybe are not as important in determining co-authorship given the greatly increased access to the web. They also address a potential problem, namely the time between when collaboration commenced and when it is noted, namely in a publication.

be found here. A rising pressure to publish would suggest that the risk-sharing argument might have considerable validity, in particular if articles are not fully discounted for number of authors.²⁵ The increased ease and cheapness of electronic communication, plus greatly reduced cost of travel, that has opened up greater possibilities for collaboration. It is in relation to these factors that the most substantial evidence has been provided, but this may simply arise from the fact that these are easier to measure. As noted earlier, it is possible also to argue that while a wider network from which to choose should change the pattern of co-authorship it does not necessarily increase the incidence of co-authorship.

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²⁵See Osterloh and Frey [2014] for a general discussion on the use of citations and rankings in economics, in particular the randomness of some of the reviewing processes. Even if this always existed to a certain extent, the non-discounting of multi-authored papers would mean that the latter would be a very useful way of countering this randomness without any loss of individual/institutional ranking.

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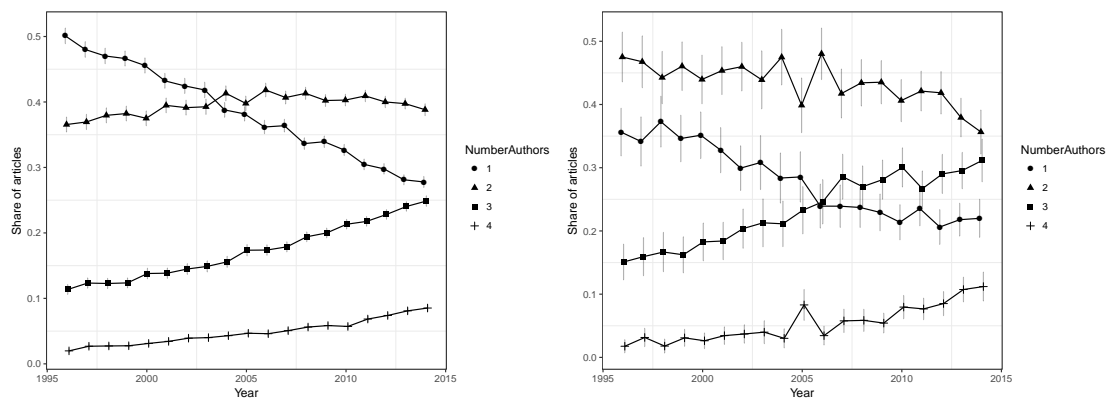
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A. Figures (to be inserted suitably in text at production stage)

Figure 1: Share of articles by number of authors

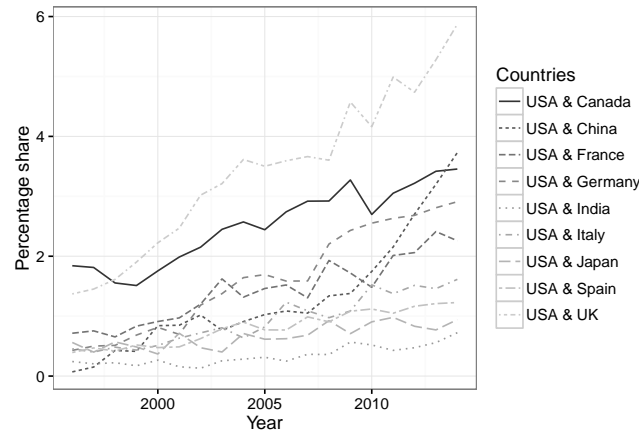


(a) Top 255 journals

(b) Top 20 journals

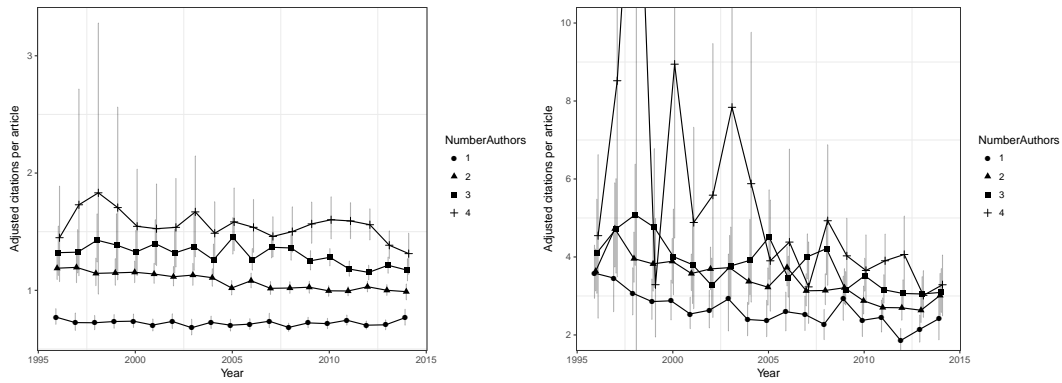
Notes: Number of economic research articles published in a top 255 or top 20 journal as described in text, classed by number of authors and divided by the yearly total number of articles. 95 % confidence intervals as vertical lines. *Source:* Own calculations based on Scopus data.

Figure 2: Co-authored papers across countries, relative to the combined paper output of the two countries



Note: Number of economics articles with author affiliations in both respective countries divided by the yearly combined article output of these countries. Affiliation countries as indexed by Web of Science. Source: Own calculations based on Web of Science data.

Figure 3: Citations received per article, relative to yearly mean, by number of authors

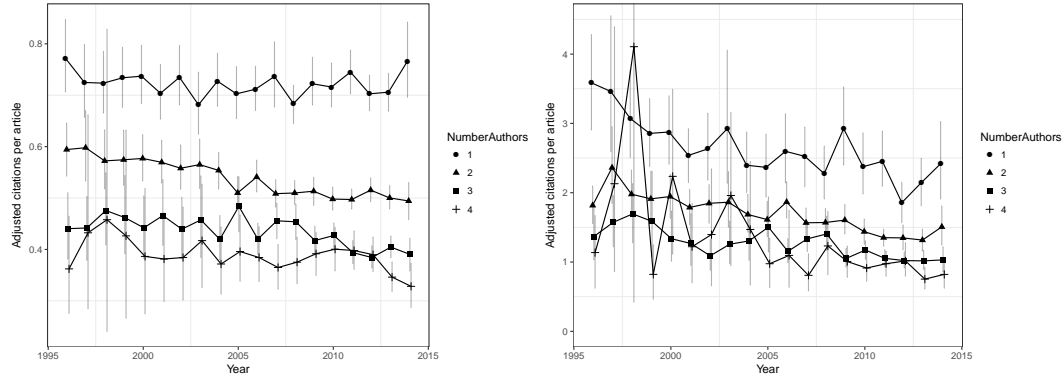


(a) Top 255 journals

(b) Top 20 journals

Notes: Means of citations to economic research articles published in a top 255 or top 20 journal as described in text, by number of authors and divided by the yearly mean of citations received per top 255 journal article. Bootstrapped 95 % confidence intervals as vertical lines. Source: Own calculations based on Scopus data.

Figure 4: Citations received per author

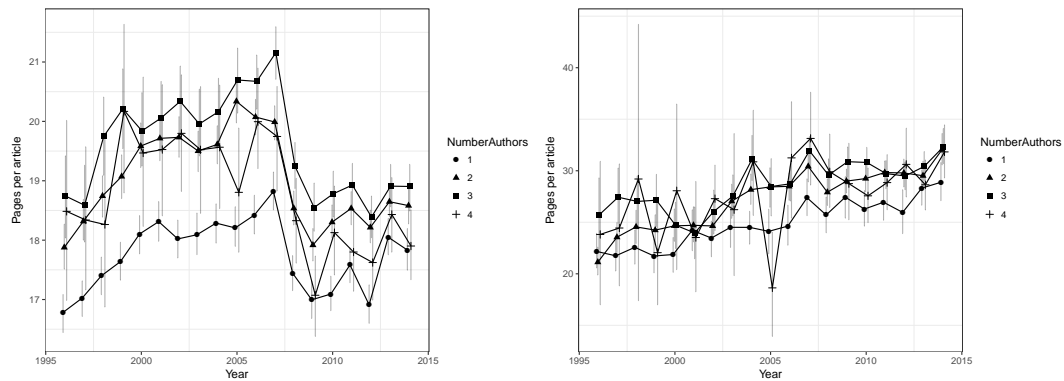


(a) Top 255 journals

(b) Top 20 journals

Notes: Means of citations to economic research articles published in a top 255 or in top 20 journal as described in text, by number of authors and divided by the number of authors and the yearly mean of citations received per top 255 journal article. Bootstrapped 95 % confidence intervals as vertical lines. Source: Own calculations based on Scopus data.

Figure 5: Number of pages

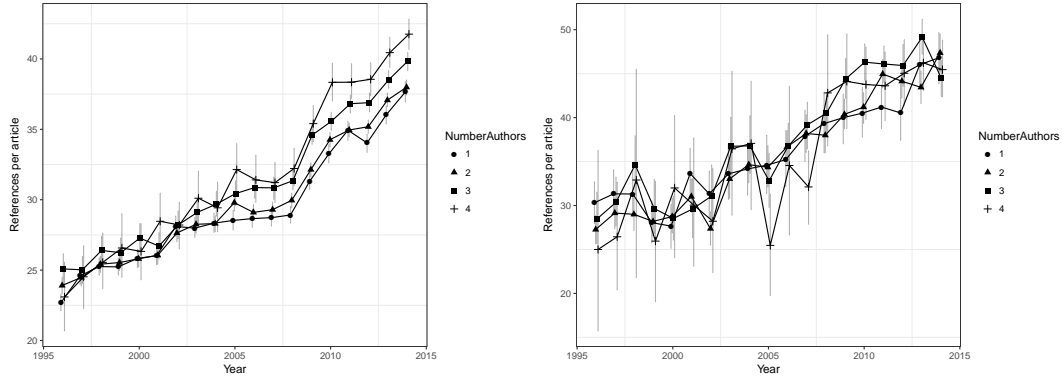


(a) Top 255 journals

(b) Top 20 journals

Notes: Means of number of pages of economic research articles published in a top 255 or in a top 20 journal as described in text. Bootstrapped 95 % confidence intervals as vertical lines. Source: Own calculations based on Scopus data.

Figure 6: Number of references given

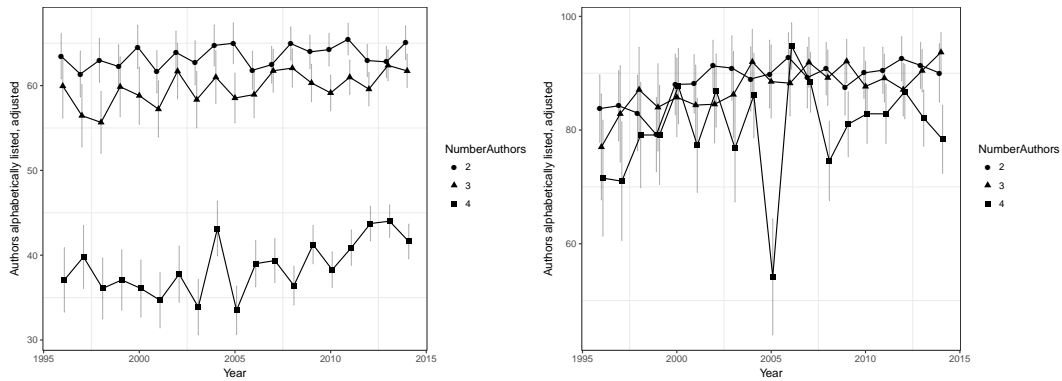


(a) Top 255 journals

(b) Top 20 journals

Notes: Means of number of references in economic research articles published in a top 255 or in a top 20 journal as described in text. 95 % confidence intervals as vertical lines. Source: Own calculations based on Scopus data.

Figure 7: Alphabetical ordering of authors

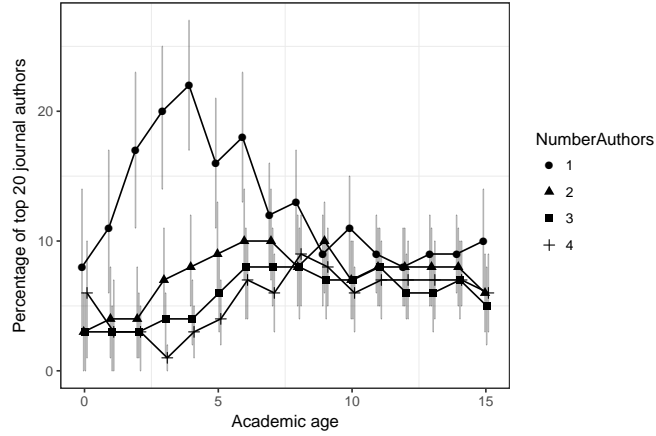


(a) Top 255 journals

(b) Top 20 journals

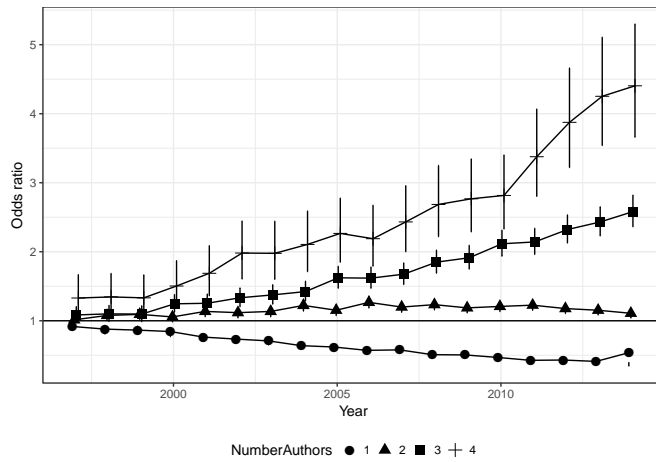
Notes: Percentages of alphabetically listed authors by number of authors and journal category. Percentage adjusted for different probabilities for random alphabetical ordering between different author group sizes. 95 % confidence intervals as vertical lines. Source: Own calculations based on online CV and Scopus data.

Figure 8: Articles by number of authors by year following award of PhD, relative to authors in top 20 journals



Note: Number of articles by year following award of PhD, as percentage of the maximal possible number given published articles in top 20 journals with the same number of authors. The maximal possible number is the number of articles in the respective category multiplied by the category's number of authors. Based on 3,874 articles by 136 highly cited economists who were awarded their first PhD between 1996 and 1999. *Source:* Own calculations based on the authors' on-line CVs and Scopus data.

Figure 9: Odds ratios for year of publication



Note: The graph shows estimated odds ratio for publication years estimated in logit regressions as reported in Table ???. The x-axis lists the year of publication of an article. *Source:* Own calculations based on Scopus data.

B. Tables (all to be placed in Appendix 1)

Table A.1: Number of pages, references given, citations received, and alphabetical listing

	<i>Dependent variable (link: log (1-3) and logit (4)):</i>			
	Pages (1)	References given (2)	Citations received (3)	Alphabetical order (4)
DuoPlus	0.056*** (0.005)	0.035*** (0.006)	0.252*** (0.017)	
TreblePlus	0.013*** (0.003)	0.023*** (0.005)	0.133*** (0.016)	-0.877*** (0.022)
QuartoPlus	0.013** (0.007)	0.011 (0.007)	0.141*** (0.031)	-0.880*** (0.050)
DuoPlus:Top20	0.041** (0.019)	-0.017 (0.020)	0.017 (0.047)	
TreblePlus:Top20	0.033** (0.016)	0.021* (0.012)	-0.048 (0.031)	0.167** (0.081)
QuartoPlus:Top20	-0.027** (0.014)	-0.052*** (0.015)	0.150 (0.114)	0.162 (0.203)
N (df)	170470 (170192)	173449 (173171)	173449 (173171)	109541 (109265)

Notes: This table reports estimated coefficients from quasi-Poisson and logit regressions with cluster robust standard errors in parentheses. The estimations include journal and year dummies and standard errors are clustered at the journal level. Each observation is an economic research article. The variables relate to the number of references given to other articles the number of pages, a dummy for alphabetical listing of authors, as well as the publication year, and whether the publishing journal is among the twenty most cited journals (per article and relative to yearly citations).

*p<0.1; **p<0.05; ***p<0.01

Table A.2: The estimates with single-authorship as reference

	<i>Dependent variable (link: log (1-3) and logit (4)):</i>			
	Pages (1)	References given (2)	Citations received (3)	Alphabetical order (4)
TwoAuthors:OtherJournal	0.056*** (0.005)	0.035*** (0.006)	0.252*** (0.017)	
ThreeAuthors:OtherJournal	0.069*** (0.006)	0.058*** (0.009)	0.385*** (0.023)	-0.877*** (0.022)
FourAuthors:OtherJournal	0.083*** (0.009)	0.069*** (0.011)	0.526*** (0.037)	-1.757*** (0.061)
TwoAuthors:Top20	0.097*** (0.018)	0.018 (0.019)	0.269*** (0.043)	
ThreeAuthors:Top20	0.143*** (0.029)	0.062*** (0.023)	0.354*** (0.046)	-0.717*** (0.074)
FourAuthors:Top20	0.129*** (0.031)	0.021 (0.022)	0.645*** (0.092)	-1.472*** (0.185)
N (df)	170470 (170192)	173449 (173171)	173449 (173171)	109541 (109265)

Notes: This table reports estimated coefficients from quasi-Poisson and logit regressions with cluster robust standard errors in parentheses. The estimations include journal and year dummies and standard errors are clustered at the journal level. Each observation is an economic research article. The variables relate to the number of references given to other articles the number of pages, a dummy for alphabetical listing of authors, as well as the publication year, and whether the publishing journal is among the twenty most cited journals (per article and relative to yearly citations).

*p<0.1; **p<0.05; ***p<0.01

Table A.3: Trends in pages, references, and citations received

	<i>Dependent variable (link: log):</i>			
	Pages (1)	References given (2)	Citations received (3)	Citations adjusted (4)
Authors2	0.078*** (0.011)	0.020 (0.015)	0.346*** (0.024)	0.304*** (0.030)
Authors2:Top20	0.006 (0.031)	-0.057* (0.034)	-0.023 (0.084)	-0.002 (0.083)
Authors2:Year	-0.002* (0.001)	0.001 (0.001)	-0.013*** (0.002)	-0.005** (0.002)
Authors2:Top20:Year	0.002 (0.003)	0.003 (0.002)	0.007 (0.008)	0.001 (0.007)
Authors3	0.116*** (0.018)	0.025 (0.019)	0.552*** (0.035)	0.450*** (0.041)
Authors3:Top20	0.058 (0.051)	-0.033 (0.035)	-0.052 (0.093)	-0.040 (0.099)
Authors3:Year	-0.004** (0.002)	0.003** (0.001)	-0.024*** (0.003)	-0.008*** (0.003)
Authors3:Top20:Year	-0.002 (0.004)	0.003 (0.003)	0.007 (0.009)	0.004 (0.009)
Authors4	0.174*** (0.028)	-0.006 (0.026)	0.759*** (0.066)	0.567*** (0.071)
Authors4:Top20	-0.100 (0.068)	-0.122 (0.092)	0.297 (0.205)	0.333 (0.211)
Authors4:Year	-0.007*** (0.002)	0.006*** (0.002)	-0.031*** (0.004)	-0.007 (0.005)
Authors4:Top20:Year	0.007 (0.005)	0.005 (0.006)	-0.019 (0.016)	-0.021 (0.015)
Year	-0.000 (0.002)	0.024*** (0.001)	-0.104*** (0.002)	0.010*** (0.003)
Top20:Year	0.018** (0.008)	0.000 (0.005)	-0.018** (0.009)	-0.026** (0.010)
N (df)	170470 (170202)	173449 (173181)	173449 (173181)	173449 (173181)

Notes: This table reports estimated coefficients from quasi-Poisson regressions with cluster robust standard errors in parentheses. The estimations include journal dummies and standard errors are clustered at the journal level. Each observation is an economic research article. The variables relate to the number of references given to other articles, pages and citations received, as well as the publication year set to one in 1996, and whether the publishing journal is among the twenty most cited journals (per article and relative to yearly citations).

*p<0.1; **p<0.05; ***p<0.01