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Predicting early career productivity of PhD economists: Does advisor-match matter?

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Abstract
We assess the role played by department rank and advisor-match on the early stage productivity of recent PhDs in economics using a tailor-made data set based on RePEc. After allowing for the potential influence of other factors, including gender and field of specialisation, we find as expected that both advisory quality and rank of the graduation institution are positively related to the academic productivity of graduates. However, in top institutions, students working with the most productive academics do not outperform others unless they co-author with their advisor. For students in non-top institutions, being advised by the best academics is always associated with a higher research output. Possible explanations for this difference are pointed out, including selection and differences in advising styles.

Keywords Academic career · Research performance · RePEC · Economic research

JEL Classification A11 · I23 · J11 · J24

Introduction

Early career research production not only helps to determine the long term impact of the research of an academic, but also provides useful information that affects job offers, tenure decisions and promotions in academia. An important factor that may be informative for making accurate predictions about the future performance of young graduates in academia is the education that they received during their doctoral training. Indeed, as indicated

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by Long and McGinnis (1985), the effects of education on the careers of academics act through two main channels. Firstly, the academic department provides an environment where quality and quantity ingredients foster students' performance during and after their doctoral training. Secondly, since faculty composition within departments is likely to be heterogeneous in willingness and style of advising, a good supervisor can shape abilities through teaching, mentorship and collaboration above and beyond what the department can do. Apart from playing a fundamental role in the transmission of knowledge, the supervisor influences the formation of academic habits, can facilitate access to research networks, and may participate in joint academic projects with the advisee.

The aim of this paper is to assess the extent to which advisory supervision, in addition to overall department quality, predicts early stage productivity of recent PhDs in economics. We define productivity as the quality adjusted number of publications within 6 years after graduation. Data on publications and supervisor–supervisee relationships are obtained from RePEc, a worldwide project that collects comprehensive information on academics in economics and related areas. The RePEc data link authors with research products (working papers, articles, book chapters and software components), number of citations and, most importantly, specific information on academic genealogy that connects graduates with their advisors. Our main regression results use a sample of 1976 individuals who obtained a PhD in Economics between the years of 2005 and 2010. Their academic production is observed over a 9-year window, starting 2 years before the completion of their degree, and ending 6 years after that.

This comprehensive data source has a number of advantages relative to those used in the prior literature that often relied on information from surveys or professional associations. First, it allows us to construct more accurate productivity measures for students, advisors and institutions that are superior to rough binary classifications used elsewhere (e.g. Top 30 economics department, Top 250 most productive—or star—advisor, publication in a Top 5 journal). Here, we focus on specific measures of productivity, namely the number of published articles with and without adjustment by the impact factor of the journal. Second, it is comprehensive regarding region, field and type of employment. This is in sharp contrast to the majority of existing studies which focus on a single region, a group of selected universities or a single subfield of economics.[1] Third, it comprises all graduates, including those affiliated to non-academic institutions (such as research centers and multilateral organizations dedicated to academic research), who are not usually considered in similar analyses in economics and other sciences (see e.g., Long and McGinnis 1981). Fourth and finally, we can identify specific collaborations between graduates and advisors as co-authors, which will be an important aspect of our analysis.

For a preview of our main results, we find that academic productivity of graduates is positively related to both program and advisor quality. While graduates from Top 25 institutions publish on average half a paper less than others (4.7 as opposed to 5.2), they have a close to 100% higher productivity when the quality of the journal is accounted for. The association with advisor quality is more nuanced: in non-Top 25 institutions, those working with more productive advisors are predicted to be more productive themselves regardless of whether there is a co-authorship or not. In Top 25 institutions, there is a large difference in predicted productivity by co-authorship. Without co-authorship, the quality of the advisor does not seem to predict the productivity of graduates from such programs.

[1] For instance, Cardoso et al. (2010) study research productivity in labour economics while Hilmer and Hilmer (2007b) consider a sample of graduates from Top 30 universities.

Empirically, co-authorship rates are substantially lower in Top 25 institutions (25%) than in non-Top 25 institutions (39%). In summary, while graduates from Top 25 institutions are more productive overall in terms of quality-adjusted output, this gap can be closed for students in non-top institutions, when they are advised by the most productive academics in their programs.

While our results are robust to different econometric specifications (OLS or Poisson pseudo maximum likelihood), they do not imply causality, since students are not randomly assigned to institutions, advisors or co-authorship. For instance, it is to be expected that more academically gifted students are placed in more selective PhD programs. Hence, the difference between outcomes in Top-25 and other institutions will tend to overstate the effect of program quality (which may even be non-existant) on individual performance. Similar arguments apply to advisor-match and selection into co-authorship, since advisors may offer co-authorship only to their most talented students. We have no information on pre-enrollment outcomes of students and consequently, as in the related literature, there is no possibility for us to shed more light on potential selection effects.

However, our empirical results are directly relevant for all decisions where predicting future productivity is relevant, such as when recruiting PhD economists, making decisions on grant applications, or deciding on promotion rules. Moreover, for prospective graduate students, it may be reassuring that the outcome distributions for Top-25 institutions and others considerably overlap: this should take a bit of weight from the importance of the admission process, as being placed in a lesser ranked program clearly does not rule out an ensuing successful research career.

The remainder of the paper is organized as follows. "Review of the literature" section provides a short review of the literature. "Data" section describes the data. "Empirical analysis" section presents the results of our empirical analysis, while "Concluding remarks" section concludes.

Review of the literature

The early-career publication performance of PhD graduates in economics has been subject to some prior investigations. Recent examples include Buchmueller et al. (1999) and Conley and Önder (2014) for the US and Canada, Bäker (2015) and Önder and Schweitzer (2017) for German speaking countries, and Hilmer and Hilmer (2007a) and Cardoso et al. (2010), who focus on agricultural economists and labor economists, respectively.

There are a number of common themes: citation analyses are eschewed because citations take time to accumulate and are uninformative at the start of ones career; publications are quality adjusted, using various sorts of journal impact factors; a window of 6 post-PhD years is chosen as this coincides with the usual tenure clock; and the samples are often convenience samples (such as AEA member surveys, Handelsblatt Ranking, or IZA summer school participants) that usually do not cover the entire population of PhD graduates.

Conley and Önder (2014) provide intriguing stylized facts on recent graduates in economics: it is the case that even in top-ranked departments, only a small percentage of PhD graduates are able to achieve a creditable number of publications within sixth years, and about half does not publish at all (see also Conley et al. 2016). Moreover, graduating from a Top department is neither necessary nor sufficient for a successful academic career. For instance, the fraction of graduates without publication is lower for

some non Top-25 departments (Carnegie-Mellon, 33.3%; UCSD, 21.7%) than it is for Harvard University (37.7%).

While there have been related early career papers for other disciplines (e.g. Long and McGinnis 1985; Broström 2019), the field-specific differences of the publication process makes it quite difficult to learn from such comparisons. For example, Long and McGinnis (1985) reports that among bio-chemists, 73% of PhDs have already a publication at the time of graduation.

A prior paper most closely related to ours is Hilmer and Hilmer (2007a). They study the determinants of early career productivity for Ph.D.s in agricultural and resource economics programs, for the period 1987–2000. Importantly, they distinguish between program and advisor quality. Information on advisors comes from the North American Dissertation Abstracts Database that includes the name of the student's dissertation advisor for the majority of dissertations. Hilmer and Hilmer (2007a) find that students with a more productive advisor have themselves more publications, ceteris paribus, for a given program. Moreover, students from lower-ranked programs working with relatively more prominent advisors outperform their peers at highly ranked programs working with less prominent advisors.

Our paper differs from Hilmer and Hilmer (2007a) in a number of dimensions. On the data side, our paper uses more recent cohorts, those graduating between 2005 and 2010, and is broader in scope. The RePEc Genealogy allows us considering PhDs from all economics programs (including agricultural and resource economics), and it is not restricted to North America. On the methodological side, we add another explanatory variable, advisor co-authorship, that helps to investigate one pathway by which advisors help their students into a publication career. Also, we complement linear regression models by Poisson pseudo likelihood estimators to account for the non-negative dependent variable.

Co-authorship is defined here in relationship to the student-advisor match, distinguishing our approach to the wider literature on general co-authorship (e.g., Cainelli et al. 2015; Henriksen 2016; Sommer and Wohlrabe 2017) as well as the network literature (e.g., Laband and Tollison 2000; Colussi 2018). This is not to deny that the increase in general co-authorship is a very marked trend in economics: for example, the share of single-authored publications fell from one half to about one quarter between 1996 and 2014 (Kuld and OHagan 2018). Although we do not have directly comparable data bearing on this question, it seems unlikely that this trend is driven by student-advisor co-authorships.

Our paper is also related to some prior work on gender of students, advisors and co-authors. Hilmer and Hilmer (2007b) find that female students, regardless of gender of their advisors, have significantly fewer publications early in their careers than men. On the other hand, Sarsons (2017) observes that men and women who publish solo exhibit similar tenure and promotion rates, conditional on the quality of the papers, but there is a penalty for women publishing with men. This finding may indicate an implicit bias against women which likely affects not only promotion but publishing success as well.

Finally, there is a large literature on the publication process in economics in general, including journal rankings (Laband 2013), and entire research careers (Conley et al. 2013). For instance, Oster and Hamermesh (1998) find that the propensity to publishing in leading journals declines with age, and that the few exceptions are those who were the most productive during the early part of their academic careers. In this sense, results presented in this paper may also be relevant for the long-term career point of view.

Data

The data used in the paper mainly come from Research Papers in Economics, RePEc. To the best of our knowledge, this is the first time that RePEc data are used to study early publication productivity and its relation to degree program and advisor. RePEc organises bibliographic data from over 1900 repositories in 98 countries with more than 2.5 million items of research from journals, working paper series, book (and book chapter) collections, and software components (in the form of usable computer codes). In addition, there are more than 50,000 registered authors.

The data collected in RePEc is distributed in a structured way in a number of so-called projects. For the purposes of our research, the most relevant projects are: IDEAS, which contains the bibliographic database; LogEc, which collects detailed information on authors' publications (journal and co-authors) as well as related statistics; Edirc, which contains a directory of economic institutions with their affiliated researchers and publications; and Genealogy, which can be thought of as an academic family tree for economists. The information contained in all RePEc projects can be merged through RePEc Author Service, which builds a public research profile with the purpose of linking authors with their research output. To achieve a good level of author name disambiguation, RePEc Author Service creates a unique and permanent identifier, referred to as "RePEc Short-ID". Since an authors name may be indexed under different variations, authors are allowed to list in their public research profile all the possible variations of their names. The search engine periodically suggests works that match the name variations provided by the authors, who are then allowed to add these works to their public research profile. In short, the RePEc Short-ID permits to identify authors throughout RePEc projects (see Zimmermann 2013).

We use web scraping techniques to retrieve the bibliographic data for all RePEc authors that appear in the Genealogy project, their training institutions and their advisors, from RePEc Genealogy, LogEc and IDEAS, respectively.[2] The total number of articles per registered author provides a simple measure of academic production, but not of its quality. Thus, to adjust for the latter we use the RePEc ranking of economics journals that (as of December 2016) was established using information on the cumulative simple impact factor (defined as the ratio of the number of citations by the number of items in each journal). RePEc data show that the Quarterly Journal of Economics is the top economics journal, and so we compute the number of Quarterly Journal of Economics equivalent articles, which we shall refer to as QJEe articles for short; see "Appendix 1" for the list of top journals.[3]

RePEc provides similar quality measures for institutions and advisors. In the case of institutions, we employ the classification (as of December 2016) which ranks economic departments according to a score based on the harmonic mean of the ranks of a number of different criteria including the number of distinct works, authors, citations, views, and H-index, among others. For the purposes of our empirical analysis, the score of the institutions is normalised between zero and one, where the Department of Economics of Harvard University occupies the first position; the list of Top 25 departments is presented in "Appendix 2". As for the publication success of the advisors, we construct a measure based

[2] The data were obtained in October 2017, using the software R and procedures written by the authors.

[3] Oswald (2007) argues that the prestige of a journal can be viewed as a short-term indicator of the quality of an article. However, in the medium- to long-term the number of citations of the articles provides a better measure of its quality.

on their cumulative QJEe academic production up to four years before the year of graduation of the advisee. Therefore, it ought to be noticed that despite the fact that our econometric analysis is based on cross-section data, the publication quality of an advisor changes depending on the moment in time in which they are chosen by the student.

In addition to the bibliographic data mentioned above, it was also possible to obtain information on the gender of the authors registered in RePEc Genealogy (for both advisors and advisees). Since authors are not required to provide their gender during the registration process, we attribute gender through an analysis of names along with a list of exceptions. To this end, we use the *Ethnea* application, a computing tool that predicts gender based on the first name, last name and predicted ethnicity of an individual.[4] It makes use of the *Genni* dataset that was trained using 85,406 names in US Social Security Administration (SSA) data during 1880–2008 to predict gender linking names and gender markers generated by Bing.com searches. This tool achieves a 97.75% classification accuracy of the people in the SSA dataset. In about three hundred cases there were uncertain matches, which were all resolved through internet search of the authors' websites.

Lastly, to have an idea of the main field of research of an individual, we use information from New Economics Papers (NEP). NEP is an announcement service created with the purpose of producing reports (generated by subject-specific editors) on new additions to RePEc. Although NEP reports comprise a total of 97 subject categories, we opt for grouping them into the classification employed by the Journal of Economic Literature (JEL); see "Appendix 3" for the field classification that we adopted.

The sample used in the following econometric analysis consists of individuals who, according to the RePEc Genealogy project, graduated between the years of 2005 and 2010. This amounts to a total of 1976 (out of the 11,700) individuals for whom we consider their academic production over a 9-year window which starts 2 years before the completion of their terminal degree, and ends 6 years after that.

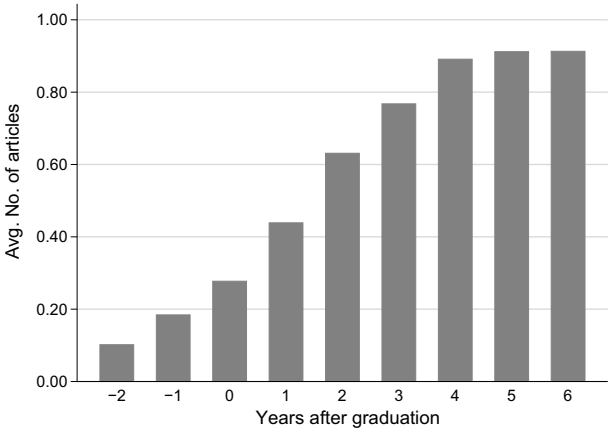
Figure 1a displays the yearly publication output of graduates of the 2005–2010 cohorts. Total output steadily increases to an average of about 0.9 paper per year in the fourth year after the terminal degree, and remains flat thereafter. The quality adjusted average number of QJEe articles continues to increase over the entire nine year period (counting pre-graduation outcomes as well), although at a markedly diminishing rate after post-graduation year four (see Fig. 1b).

How representative can our matched student-advisor sample possibly be? The RePEc Author register itself is without doubt the most comprehensive database on academic economists that exists. If anything, it may underrepresent PhD graduates that never published a single item (including working papers) which is unlikely to matter in practice. However, users registered in the genealogy are clearly positively selected in terms of research output. Overall, they represent about 20% of RePEc authors but almost half of all publications (Orazbayev 2017).

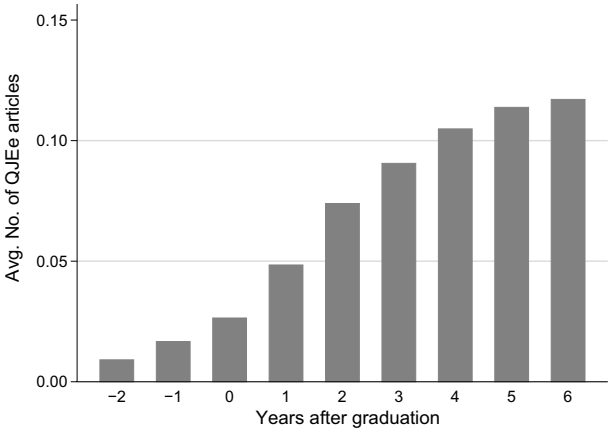
The selection problem may be somewhat attenuated in our 2005–2010 sample since genealogy data itself are tilted towards younger cohorts, as can be seen from Fig. 2. Actual cohort sizes have remained rather stable over the last two decades, so the disproportionate presence in the genealogy is rather a sign of increasing participation, reflecting in part the changing usage patterns of those growing up in the digital age.[5]

[4] See http://abel.lis.illinois.edu/cgi-bin/ethnea/search.py.

[5] According to Conley et al. (2013) there are about 1000 PhD economists graduating each year in North America.



(a) Avg. No. of articles per year



(b) Avg. No. of QJEe articles per year

Fig. 1 Yearly academic production of graduates 2005–2010 cohorts

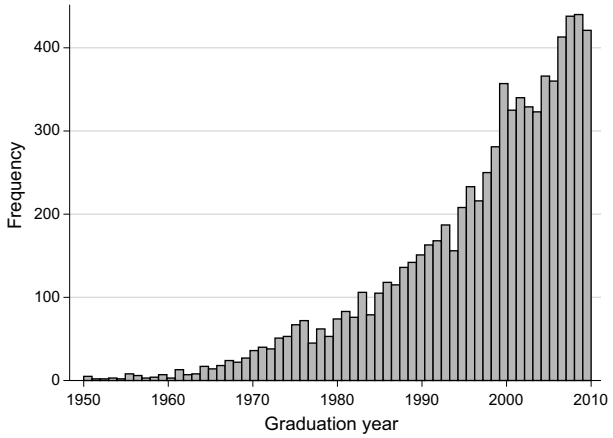
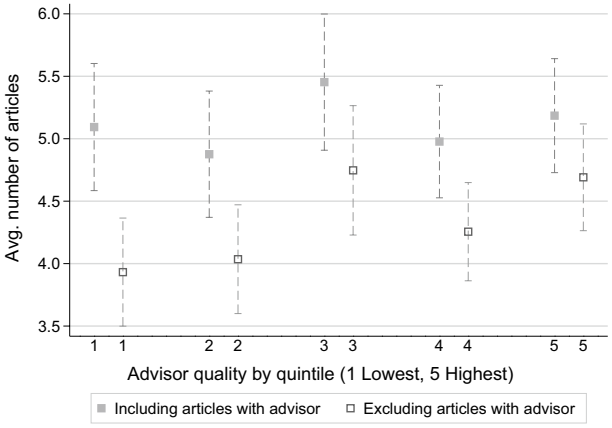
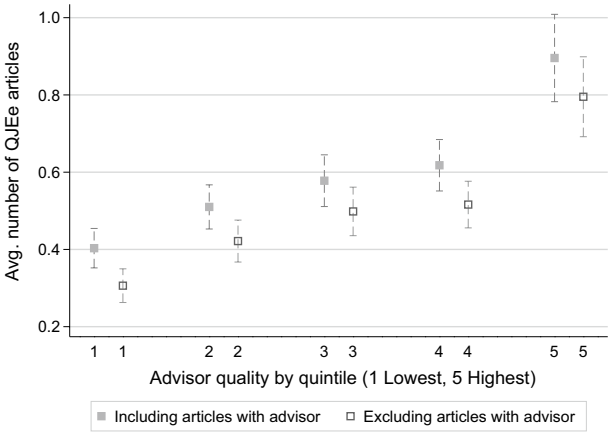


Fig. 2 Cohort sizes in the RePEc genealogy



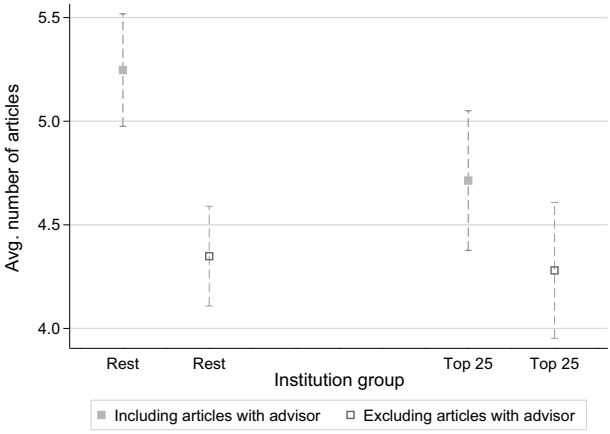
(a) Avg. number of articles



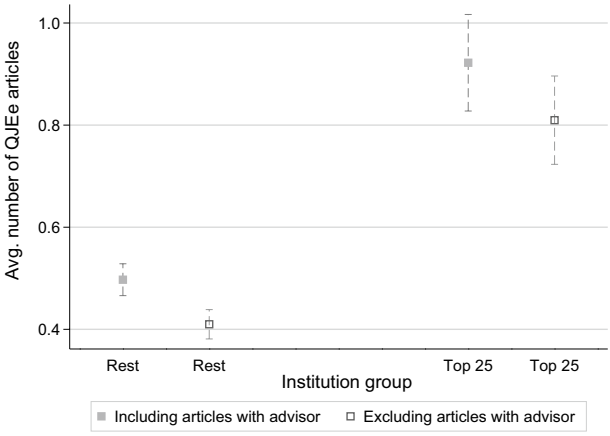
(b) Avg. number of QJEe articles

Fig. 3 Articles six years after graduation by advisor quality (quintiles)

While it is not possible for us to exactly determine publication activity for the part of the 2005–2010 graduation cohort not present in the genealogy, we find for example that within the genealogy data, only 8.25% have not published anything within six years after graduation. This falls substantially short of the aforementioned non-publication rate of 50% reported in Conley et al. (2016) for PhDs graduating from U.S. institutions between 1987 and 1996. Also, within our data, those with complete information have more publications after 6 years (on average 5.12 as compared to 4.62) than those who do not (for QJEe, the means are 0.60 and 0.44, respectively). Incomplete information here means missing values for gender (student and advisor) and/or adviser's experience. Overall, the evidence points toward a positively selected sample which should be kept in mind when interpreting descriptive statistics and which, when it comes to regression analyses, may lead to some attenuation bias of the estimated associations.



(a) Avg. number of articles



(b) Avg. number of QJEe articles

Fig. 4 Articles six years after graduation by institution quality

Empirical analysis

Our empirical analysis revolves around the question of whether, and how much, advisor quality and/or quality of the economics doctoral programs predicts individual variation in academic productivity during the first six years after the completion of the terminal degree.

Figure 3 plots the average number of articles six years after graduation against advisor quality, where the latter is measured in quintiles (error bars denote 95% confidence intervals). In particular, as can be seen in Fig. 3a the average total number of articles does not appear to vary by the quality-quintile of the advisor.

However, a different picture emerges when the number of articles is adjusted by quality, i.e., expressed in terms of QJE-equivalent papers, as seen in Fig. 3b. In this case, there is a clear positive association between advisor quality and the number of QJEe articles six years after graduation.

There are two possible channels through which advisors can have an effect on the productivity of advisees. One is directly through co-authorships, the other is indirect through passing on know-how of doing academic research. To disentangle these two channels, we

display in Fig. 3b also the relationship between advisor quality and the number QJEe articles net of those co-authored with the advisor. The positive relationship identified earlier is largely unaffected.

Next, we consider evidence on the relationship between research performance of graduates and institution quality. We distinguish two groups of institutions, namely those ranked in the Top 25, and the rest. Figure 4 shows that when one looks at the number of articles, graduates from top institutions tend to publish somewhat less than their counterparts from the rest of institutions (error bars denote 95% confidence intervals). But in terms of quality-adjusted publications, graduates from the Top 25 institutions publish about twice as much as their counterparts (see Fig. 4b). In sum, this preliminary evidence supports the view that both institution and advisor quality are important determinants of early research performance among academic economists.

Results from a linear regression model

To disentangle the contributions of advisor quality and that of economics departments, we estimate several regression models for the determinants of early academic production. We specifically consider two outcomes of interest, namely: the total number of QJEe articles (*ArtQJEe*), and the total number of articles net of those co-authored with the advisor (*ArtQJEeNet*).

The regressions include a cumulative measure of quality-adjusted academic production by the advisor at the moment he/she is chosen by the advisee, which is assumed to have occurred four years before graduation year (*AdvQJEe*); a normalised score for the quality of the economics department (*UniRank*) which is a continuous variable between 0 and 1 based on the (December 2016) RePEc classification, where 1 is the value for Harvard University; a variable that measures advisor tenure given by the number of years since the advisor's first published article (which enters the models both linearly and quadratically, denoted by *AdvTenure* and $AdvTenure^2$, respectively); and additional (indicator dummy variable) controls to account for whether or not advisor and advisee have co-authored articles (*Coauthorship*). Further regressors are a set of gender interaction terms (*Male*×*AdvFemale*, *Female*×*AdvMale*, *Female*×*AdvFemale*), as well as 17 dummies for the academic field of interest (*Field*). The regression intercept gives the predicted publication output for the group against which comparisons are made, namely male student with male advisor, specialised in JEL field A (i.e., General Economics, Teaching), and without co-authored articles with advisor.

Before presenting the regression results, Table 1 provides some descriptive statistics of the variables, separately for students who obtained their terminal degree from a Top 25 institution and those who did not. As previously discussed, there is no substantial difference in the number of articles published by students from Top 25 institutions as compared to the rest; however, noticeable differences are found when the comparison is based on measures adjusted by quality (i.e., 0.922 and 0.497 QJEe articles on average respectively for Top 25 institutions and the rest).

With respect to advisor quality, the average number of QJEe articles in Top 25 institutions is about three times the average observed in the rest of institutions (8.6 and 3.0, respectively). Although researchers in top institutions tend to be more productive on average, there are also highly productive individuals in the rest of institutions, as illustrated in Fig. 5. In terms of co-authorship with the advisor, the percentage of students who do so in top institutions is lower (24.5%) than that observed in the students from non-top

Table 1 Descriptive statistics by institution group

	Top 25		Rest		All	
	Mean	SD	Mean	SD	Mean	SD
Articles	4.714	3.773	5.247	5.350	5.117	5.016
ArtQJEe	0.922	1.059	0.497	0.616	0.601	0.770
ArtQJEeNet	0.810	0.969	0.410	0.567	0.507	0.708
AdvQJEe	8.638	10.192	2.968	3.427	4.351	6.333
Coauthorship	0.245	0.430	0.385	0.487	0.351	0.477
AdvTenure	16.751	6.783	15.307	6.721	15.659	6.763
UniRank	0.274	0.304	0.010	0.013	0.074	0.189
Male × *AdvMale*	0.737	0.441	0.694	0.461	0.704	0.456
Male × *AdvFemale*	0.046	0.209	0.046	0.210	0.046	0.210
Female × *AdvMale*	0.201	0.401	0.238	0.426	0.229	0.420
Female × *AdvFemale*	0.017	0.128	0.021	0.145	0.020	0.141
Observations	482	482	1494	1494	1976	1976

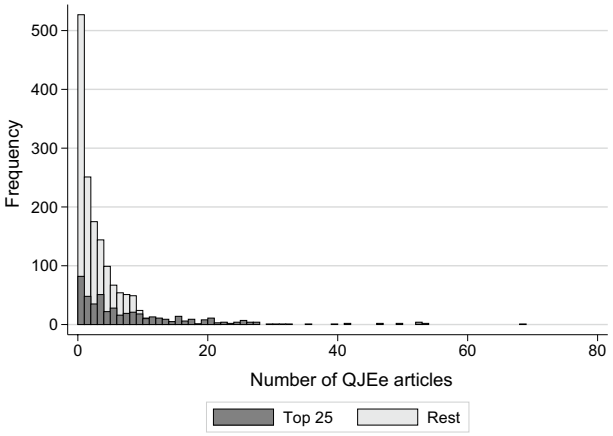


Fig. 5 Histogram of *AdvQJEe* by institution ranking

institutions (38.5%). The average number of years of experience of the advisors is about the same regardless of the quality of the institution. Lastly, almost 95% of the students in the sample are advised by a male professor. Around 20% of the graduates are female.

Table 2 reports OLS regression results where the dependent variable is the number of QJEe articles. When one pools observations for all institutions (column (1)), both the quality of the advisor (*AdvQJEe*) and that of the economics department (*UniRank*) (in percent) have a positive and statistically significant effect on the number of quality-adjusted publications after 6 years of graduation. For example, moving up the UniRank score by 0.1 is associated with an increased QJEe number of 0.11, or about 18% of the total average of 0.6; an advisor with one additional QJE or equivalent paper increases the own average by 0.012.

The tenure (years of expertise) of the advisor has an inverted U-shaped effect (with a maximum point occurring at about 10 years of experience). Co-authorship with the advisor

Table 2 OLS results for the number of QJEe articles by institution group

	All	Top 25	Rest	All	Top 25	Rest
	(1)	(2)	(3)	(4)	(5)	(6)
AdvQJEe	0.012*	0.001	0.037*	0.003	− 0.004	0.029*
	(0.005)	(0.006)	(0.010)	(0.006)	(0.007)	(0.012)
Coauthorship	0.243*	0.555*	0.188*	0.119*	0.386*	0.139*
	(0.037)	(0.129)	(0.033)	(0.038)	(0.125)	(0.045)
AdvQJEe × *Coauth.*				0.032*	0.021*	0.017
				(0.010)	(0.010)	(0.016)
AdvTenure	0.019*	0.021	0.015	0.019*	0.020	0.016†
	(0.009)	(0.026)	(0.009)	(0.009)	(0.026)	(0.009)
$AdvTenure^2$	− 0.001*	−0.001	− 0.001*	− 0.001*	− 0.001	− 0.001*
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
$UniRank \times 10^2$	0.011*	0.010*	0.021	0.012*	0.011*	0.022
	(0.002)	(0.002)	(0.016	(0.002)	(0.002)	(0.016)
Male × *AdvFemale*	− 0.103	− 0.261†	− 0.043	− 0.111	− 0.264†	− 0.047
	(0.071)	(0.150)	(0.080)	(0.071)	(0.151)	(0.080)
Female × *AdvMale*	− 0.158*	− 0.244*	− 0.163*	− 0.159*	− 0.237*	− 0.164*
	(0.032)	(0.090)	(0.030)	(0.032)	(0.090)	(0.030)
Female × *AdvFemale*	− 0.123	0.060	− 0.143*	− 0.124	0.056	− 0.146*
	(0.097)	(0.394)	(0.059)	(0.095)	(0.386)	(0.059)
Constant	0.491	0.675	0.445	0.542	0.727	0.466
	(0.104)	(0.312)	(0.078)	(0.104)	(0.310)	(0.080)
Observations	1976	482	1494	1976	482	1494
Field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.197	0.284	0.128	0.210	0.291	0.130

Standard errors in parentheses. † $p < 0.10$, * $p < 0.05$

also has a positive and statistically significant association, but it is less than one, both because there may be some crowding-out of own papers and because we consider here quality adjusted publications, with an overall mean of 0.6. Female graduates publish fewer papers than their male homologues, but for a given advisee, the difference between male and female advisors is statistically insignificant, a finding similar to that of Hilmer and Hilmer (2007b).

To allow for potential heterogeneity in the association between advisor quality and publication productivity, we split the sample between Top 25 economics departments and the rest. Results indicate that the importance of advisor productivity differs indeed. In the case of Top 25 institutions (column (2)) the advisor coefficient is small and not statistically significant. When one estimates the model using the observations for the rest of the institutions (column (3)), the point estimate of advisor quality is statistically significant and about three times that obtained for the full sample, while the ranking of the PhD granting department becomes insignificant.

One potential explanation for the apparent difference in the relative importance of advisors is that the faculty composition in terms of publication productivity is more equal in Top 25 institutions. Indeed, the coefficient of variation is 1.16 in Top 25 institutions and

1.32 in others, and the share of publications going to the 10% most productive advisors is 36% in Top 25 departments as compared to 41% for the rest. But these differences appear too small to make a real differences. Other reasons, such as advising styles, the importance of learning from peers, and the nature of the selection process into the programs and into an advisor-match surely matter as well.

Overall, these findings corroborate earlier results by Hilmer and Hilmer (2007a) that working with the most productive advisors may be more important for students (in their case of agricultural and resourse economics) in lower tier departments than for those in Tier 1 departments. Here as there, students from lower-ranked programs who work with relatively more productive dissertation advisors can outperform students from highly ranked programs working with less proctive advisors in terms of publication success.

So far, we considered the direct effects of advisor and program "quality", although the regressions in Table 2 condition on another related variable, direct co-authorship of student and advisor. The first three columns only include the main effect, the second three columns also its interaction with the number of QJEe articles produced by the advisor (*AdvQJEe* × *Coauth.*). The coefficient of co-authorship is only a fraction of one in Table 2 because we consider quality adjusted publications here, and there may be some crowding out of other papers through co-authored ones as well. Interestingly, once the interaction is included, we find that advisor productivity becomes predictive for graduates' productivity from Top-25 departments, but only when there is a direct collaboration leading to co-authorship. For other institutions, the advisor effect exists regardless of co-authoring. One possible explanation is a quantity–quality trade-off, whereby more productive faculty in highly ranked institutions tends to publish fewer papers with higher QJE equivalence weight, making a co-authorship less likely but more "profitable" for the student when it happens.[6]

To quantify the relevance of advising as a determinant of academic productivity, we use the estimates in columns (5) and (6) of Table 2 to compute the effect of having different advisor quality in a given environment. In particular, we use the regression results to predict the productivity of those with a top quality advisor and of those with an "average" one, within a framework in which both advisor and advisee are co-authors. To this end, we assume a top advisor is one for whom *AdvQJEe*=14.8; this is the average number of QJEe articles associated to the Top 20 advisors in the Top 25 economics departments in the sample. As a benchmark, the average number of QJEe articles for an "average" advisor is assumed to be equal to *AdvQJEe*=4.4, which is consistent with the average value observed in all the sample. The resulting difference in predicted outout for a graduate from a Top 25 institution, maintaining everything else the same, is 0.4 (with a standard deviation of 0.07). Performing the same exercise for a student from the rest of departments, the change in predicted academic production is equal to 0.63 (with a standard deviation of 0.13). When compared to the average number of quality-adjusted papers (*ArtQJEe*=0.60), these changes in academic production amount to approximately 67% and 104%, respectively. If instead advisor and advisee have no co-authored papers, the change in quality-adjusted production is − 0.036 (with standard deviation of 0.07) for a Top 25 economics graduate, and 0.31 (with standard deviation of 0.13) for the rest. This finding highlights that the advisor's influence on students through direct cooperation is pretty important.

Of course, the effect of co-authorship on output is partly mechanical, because it requires at least one publication by the graduate. As an alternative, we consider in Table 3 results

[6] Indeed, the gap between total publications and net publications in Fig. 3a indicates the amount of co-authoring: it is shrinking as a function of advisor quintile.

Table 3 OLS results for the number of QJEe articles net of advisor by institution group

	All	Top 25	Rest	All	Top 25	Rest
	(1)	(2)	(3)	(4)	(5)	(6)
AdvQJEe	0.011*	0.002	0.032*	0.005	− 0.002	0.029*
	(0.005)	(0.006)	(0.009)	(0.006)	(0.006)	(0.012)
Coauthorship	− 0.023	0.097	− 0.036	− 0.104*	− 0.048	− 0.055
	(0.032)	(0.109)	(0.030)	(0.033)	(0.114)	(0.040)
AdvQJEe × *Coauth.*				0.021*	0.018†	0.007
				(0.008)	(0.009)	(0.014)
AdvTenure	0.015†	0.013	0.013	0.015†	0.012	0.013
	(0.009)	(0.025)	(0.009)	(0.009)	(0.025)	(0.009)
$AdvTenure^2$	− 0.001†	− 0.000	− 0.001*	− 0.001†	− 0.000	− 0.001*
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
$UniRank \times 10^2$	0.009*	0.009*	0.017	0.010*	0.094*	0.017
	(0.002)	(0.002)	(0.015)	(0.019)	(0.021)	(0.016)
Male × *AdvFemale*	− 0.096	− 0.258†	− 0.038	− 0.102	− 0.261†	− 0.040
	(0.068)	(0.142)	(0.076)	(0.068)	(0.143)	(0.076)
Female × *AdvMale*	− 0.148*	− 0.243*	− 0.145*	− 0.149*	− 0.237*	− 0.145*
	(0.029)	(0.086)	(0.028)	(0.029)	(0.086)	(0.028)
Female × *AdvFemale*	− 0.102	0.073	− 0.127*	− 0.102	0.069	− 0.128*
	(0.094)	(0.393)	(0.053)	(0.093)	(0.387)	(0.053)
Constant	0.492	0.689	0.443	0.525	0.733	0.451
	(0.100)	(0.306)	(0.073)	(0.100)	(0.304)	(0.074)
Observations	1976	482	1494	1976	482	1494
Field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.173	0.248	0.092	0.180	0.254	0.093

Standard errors in parentheses. † $p < 0.10$, * $p < 0.05$

when the dependent variable excludes the number of QJEe articles co-authored with the advisor. The estimated coefficients are qualitatively similar to those reported in Table 2. For example, in the case of the gender interactions, the estimated coefficients are all negative and in several cases statistically significance. Likewise, the main conclusion regarding the contributions of institution and advisor quality on academic productivity continue to hold (see columns (5) and (6)); that is, the former has a positive and statistically significant coefficient for Top 25 institutions, while advisor quality is important among the rest of the institutions. Interestingly, although the individual coefficient of *Coauthorship* in a Top 25 department is statistically insignificant (i.e., − 0.048 with a standard error of 0.114), when it is interacted with *AdvQJEe* the overall contribution becomes positive for given advisor quality values above 3 QJEe articles (recall that the average value of *AdvQJEe* within Top 25 institutions is 8.6 QJEe articles).

Poisson-pseudo maximum likelihood results

While the number of articles published is a proper count, the number of QJE-equivalent articles is not. Yet it shares two key aspects of a count, a discrete probability mass at

Table 4 PPML results for the number of QJEe articles by institution group

	Including advisor			Excluding advisor		
	All	Top 25	Rest	All	Top 25	Rest
	(1)	(2)	(3)	(4)	(5)	(6)
AdvQJEe	0.008	0.002	0.058*	0.007	0.002	0.057*
	(0.005)	(0.005)	(0.019)	(0.005)	(0.005)	(0.019)
Coauthorship	0.284*	0.463*	0.377*	− 0.181*	− 0.024	− 0.095
	(0.056)	(0.114)	(0.080)	(0.066)	(0.142)	(0.091)
AdvQJEe × *Coauth.*	0.016*	0.006	− 0.004	0.021*	0.012†	0.002
	(0.006)	(0.006)	(0.019)	(0.006)	(0.007)	(0.019)
AdvTenure	0.032*	0.017	0.039*	0.031†	0.008	0.041†
	(0.016)	(0.027)	(0.020)	(0.018)	(0.030)	(0.023)
$AdvTenure^2$	− 0.001*	−0.001	− 0.002*	− 0.001†	− 0.000	− 0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$UniRank \times 10^2$	0.011*	0.009*	0.057*	0.011*	0.008*	0.055†
	(0.013)	(0.001)	(0.028)	(0.001)	(0.001)	(0.032)
Male × *AdvFemale*	− 0.172	− 0.307	− 0.090	− 0.188	− 0.341	− 0.097
	(0.141)	(0.227)	(0.179)	(0.156)	(0.240)	(0.200)
Female × *AdvMale*	− 0.290*	− 0.214*	− 0.371*	− 0.324*	− 0.268*	− 0.388*
	(0.061)	(0.101)	(0.071)	(0.067)	(0.111)	(0.079)
Female × *AdvFemale*	− 0.207	0.141	− 0.352*	− 0.201	0.145	− 0.383*
	(0.197)	(0.370)	(0.150)	(0.225)	(0.386)	(0.172)
Constant	− 0.598	− 0.205	− 0.898	− 0.619	− 0.183	− 0.901
	(0.156)	(0.266)	(0.176)	(0.177)	(0.300)	(0.200)
Observations	1976	482	1494	1976	482	1494
Field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
pseudo R^2	0.222	0.341	0.136	0.189	0.292	0.093
p-val GNR	0.013	0.148	0.030	0.005	0.270	0.025
λ_1	1.385	1.253	1.438	1.313	1.180	1.474
$se(\lambda_1)$	0.126	0.174	0.130	0.090	0.169	0.103

Standard errors in parentheses. † $p < 0.10$, * $p < 0.05$

zero and a necessarily non-negative mean. In such a situation, it is useful to consider an exponential regression model, $E(y_i|x_i) = \exp(x_i'\beta)$. In contrast to OLS, this approach always yields non-negative predictions, and moreover is easy to interpret as the coefficients are (constant) semi-elasticities.[7] In principle, a number of consistent estimators of the parameters of the exponential conditional expectation model are available, including

[7] As pointed out by Santos Silva and Tenreyro (2006), estimating a linear regression model on the log-transformed dependent variable is not advisable, first because it cannot deal with zero outcomes (for *ArtQJEe*, approximately 10% of the cases are zeros), and second, because parameters can be interpreted as semi-elasticities only under very strong independence assumptions (e.g. the absence of heteroskedasticity) that are often violated in practice.

non-linear least squares. Here, we shall follow the advice of Santos Silva and Tenreyro (2006) who, based on an extensive set of Monte Carlo simulations, recommend using the Poisson pseudo-maximum likelihood (PPML) estimator, which implies an unweighted zero-correlation moment condition between the residuals and the covariates.

The results of applying the PPML estimation procedure to the quality-adjusted measure of academic production are summarised in Table 4, where columns (1) to (3) display the results when using *ArtQJEe* as dependent variable, while (4) to (6) present those for *ArtQJEeNet*. For example, based on column (1), a coauthorship increases the predicted number of QJE equivalent papers by 28.4%, ceteris paribus. We also find that the quality of the economics department (*UniRank*) has a positive and statistically significant association, with a point estimate that is much smaller for the Top 25 departments than for the rest. The number of QJEe papers of the advisor is predictive with a positive and statistically significant coefficient only for the rest of departments. Gender interactions, when statistically significant, are negatively related to the number of QJEe articles of students, regardless of whether the number of articles co-authored with the advisor are deducted or not. The PPML results regarding the differential role of advisor quality in the two groups of institutions remain stable. Also, although the point estimates of *UniRank* are now positive and statistically significant for both Top 25 and the rest of institutions, the associated semi-elasticity is much larger for the top institutions (i.e., 0.259 as opposed to 0.074).

One feature that could be formally tested for a PPML specification is whether or not the conditional variance $\mathrm{Var}(y_i|x_i)$ is proportional to the conditional expectation $\mathrm{E}(y_i|x_i)$, i.e., $\lambda_1 = 1$ in $\mathrm{Var}(y_i|x_i) = \lambda_0 \mathrm{E}(y_i|x)^{\lambda_1}$. While proportionality is not necessary for the consistency of the estimator, other methods would be more efficient if it failed in the application. We therefore report at the bottom of Table 4 results for Gauss-Newton regression (GNR) test (see Santos Silva and Tenreyro 2006). In a few instances, the null of proportionality is rejected, but mostly it holds (see in particular also Table 5). We furthermore estimated models with a quadratic variance function but since the results were qualitatively similar, they are not reported here.

Thus far, our empirical analysis has been unequivocal in terms of importance of advisor and institution quality for predicting total academic production, and also with respect to the differentiated effect for groups of economics departments. We conclude our analysis by assessing the robustness of our results to a different outcome measure, namely one where all puplications in a Top-25 (or Top-5) journal are given a weight of "one", and all publications outside the Top-25 a weight of "zero" (rather than using RePEc derived QJE equivalent weights). In this case, there is even more emphasis on quality, and the possibility of trading off quantity against quality is reduced. The dependent variable is now a genuine count, and the parameters of the model can again be estimated using Poisson pseudo maximum likelihood.

The results, reported in columns (1) to (3) of Table 5, reveal that the quality of the advisor is not statistically significant for students from Top 25 institutions but for those from the rest. Co-authoring with the advisor increases the chances of publishing in a Top 5 journal, regardless of whether one is considering a student from a Top 25 economics department or not. As for the quality of economics department, it is significant for Top 25 institutions but not for the rest. Qualitatively similar results are obtained when the coverage of the dependent variable is extended to the Top-25 journals. (see columns (4) to (6)). Finally, the GNR test confirm the validity of the proportionality condition of the conditional variance in all estimated models.

Table 5 PPML results for the number of articles in top journals by institution group

	Top 5 journals			Top 25 journals		
	All	Top 25	Rest	All	Top 25	Rest
	(1)	(2)	(3)	(4)	(5)	(6)
AdvQJEe	0.008	0.007	0.179*	0.012†	0.002	0.130*
	(0.010)	(0.013)	(0.037)	(0.007)	(0.006)	(0.026)
Coauthorship	0.200	0.731*	0.351	0.197†	0.594*	0.398*
	(0.214)	(0.306)	(0.388)	(0.104)	(0.153)	(0.168)
AdvQJEe × *Coauth.*	0.034*	0.010	− 0.065	0.021*	0.003	− 0.026
	(0.013)	(0.018)	(0.051)	(0.008)	(0.008)	(0.029)
AdvTenure	0.121†	0.074	0.236*	− 0.000	− 0.018	0.031
	(0.068)	(0.087)	(0.095)	(0.027)	(0.033)	(0.042)
$AdvTenure^2$	− 0.004*	− 0.003	− 0.009*	− 0.000	0.001	− 0.002
	(0.002)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)
$UniRank \times 10^2$	0.023*	0.015*	0.047	0.016*	0.009*	0.072
	(0.003)	(0.003)	(0.136)	(0.002)	(0.002)	(0.055)
Male × *AdvFemale*	− 0.576	− 1.245	− 0.071	− 0.253	− 0.319	− 0.189
	(0.594)	(0.996)	(0.740)	(0.244)	(0.340)	(0.329)
Female × *AdvMale*	− 0.355	− 0.119	− 0.757†	− 0.256*	− 0.198	− 0.403*
	(0.246)	(0.293)	(0.394)	(0.102)	(0.128)	(0.154)
Female × *AdvFemale*	− 0.040	0.453	− 0.384	0.126	0.428	− 0.170
	(0.720)	(0.984)	(0.983)	(0.302)	(0.349)	(0.310)
Constant	− 2.938*	− 2.106*	− 4.384*	− 0.584*	0.038	− 1.376*
	(0.566)	(0.725)	(0.914)	(0.249)	(0.316)	(0.389)
Observations	1924	469	1380	1976	482	1494
Field dummies	Yes	Yes	Yes	Yes	Yes	Yes
pseudo R^2	0.180	0.264	0.040	0.171	0.269	0.086
p-val GNR	0.871	0.944	0.591	0.090	0.662	0.034
λ_1	1.011	1.007	1.097	1.162	1.077	1.386
se(λ_1)	0.067	0.097	0.127	0.089	0.180	0.103

Standard errors in parentheses. † $p < 0.10$, * $p < 0.05$

Concluding remarks

The key finding of our study is that students attending a less prestigious economics PhD program can perform as well as students from highly ranked programs, provided they work with the most research-active dissertation advisors. In Top-25 programs, the research productivity of the advisor does not predict publication rates unless the advisor co-authors with the student.

Most students in Top-25 departments do not co-author with their advisor, and for those students, the fact that the productivity of the advisor does not make a difference for them may be due to advising style. For instance, advisors in Top-25 departments may generally be less involved with their students than in lower ranked ones. It might also be the case that

peer effects are stronger in top institutions, driven by higher quality students interacting in a better environment. But these are conjectures only.

Alternatively, the difference in the importance of advisors could be a pure selection effects: in lower ranked departments, there may be more heterogeneity in the student intake, and subsequent sorting leads to the most able students being matched to the best advisors. In Top-25 institutions (and even more so in the Top-10 or Top-5), students are already so highly selected at admission, that there is little room for further selection within the program among advisors. With the data we possess, we cannot distinguish between these possibilities, and it would be interesting in future research to shed more light on the selection process, as indeed also on the "production process", adding e.g. information on faculty-student ratios, curricula details, and the like.

About 25% of all graduates in our sample are women. Women in average are predicted to publish fewer QJE equivalent articles than men. There is one interesting exception, though, namely women in Top-25 departments working with a female advisor. The field fixed effects are always statistically significant as a group. A below average number of publications is predicted for instance for industrial organization and agricultural economics. An important lesson from our study is that for the purpose of predicting publication success, it is insufficient to consider the rank of the PhD granting institution only. Instead, incorporating information on gender, field and publication productivity of the advisor will lead to more accurate predictions.

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Compliance with ethical standards

Conflict of interest The authors have no competing interests.

Appendix 1: List of top journals

(1) Quarterly Journal of Economics; (2) Journal of Economic Literature; (3) Journal of Political Economy; (4) Econometrica; (5) Journal of Economic Growth; (6) Journal of Financial Economics; (7) Review of Economic Studies; (8) Journal of Economic Perspectives; (9) Journal of Finance; (10) Economic Policy; (11) Review of Financial Studies; (12) American Economic Review; (13) Journal of Monetary Economics; (14) Brookings Papers on Economic Activity; (15) Journal of Labor Economics; (16) Journal of Econometrics; (17) American Economic Journal: Macroeconomics; (18) Journal of the European Economic Association; (19) Economic Journal; (20) Rand Journal of Economics; (21) Review of Economics and Statistics; (22) Journal of Applied Econometrics; (23) World Bank

Economic Review; (24) Journal of Human Resources; (25) American Economic Journal: Applied Economics;

The list does no include the Journal of Business, which stopped being published in 2006. Similarly, Proceedings, Federal Reserve Bank of San Francisco; Proceedings, Federal Reserve Bank of Cleveland; Western Economic Developments, Federal Reserve Bank of San Francisco; and Quarterly Review, Federal Reserve Bank of Minneapolis, are not included either because they tend to rely on invited papers.

Appendix 2: List of top departments

(1) Harvard; (2) MIT; (3) Princeton; (4) UC-Berkeley; (5) Chicago; (6) Oxford; (7) Paris School of Economics; (8) Stanford; (9) NYU; (10) Toulouse School of Economics; (11) Columbia; (12) Yale; (13) Brown; (14) Boston; (15) Barcelona Graduate School of Economics; (16) UC-San Diego; (17) Dartmouth College; (18) Michigan; (19) Pennsylvania; (20) LSE; (21) Northwestern; (22) UCL; (23) Columbia (Finance); (24) British Columbia; (25) Wisconsin-Madison.

Appendix 3: Field classification

The capital letter in parentheses is the JEL classification. The three small-case letters in parentheses refer to the nep classification.

(A) General Economics, Teaching: (soc) Social Norms and Social Capital, (sog) Sociology of Economics.

(B) History of Economic Thought, Methodology, Heterodox Approaches: (hme) Heterodox Microeconomics, (hpe) History and Philosophy of Economics, (pke) Post Keynesian Economics, (pol) Positive Political Economics.

(C) Mathematical, Quantitative Methods: (big) Big Data, (cmp) Computational Economics, (dcm) Discrete Choice Models, (ecm) Econometrics, (evo) Evolutionary Economics, (exp) Experimental Economics, (for) Forecasting, (gth) Game Theory, (ore) Operations Research.

(D) Microeconomics: (cbe) Cognitive and Behavioural Economics, (cdm) Collective Decision-Making, (cta) Contract Theory and Applications, (des) Economic Design, (ets) Econometric Time Series, (ipr) Intellectual Property Rights, (knm) Knowledge Management and Knowledge Economy, (mic) Microeconomics, (net) Network Economics, (neu) Neuroeconomics, (upt) Utility Models and Prospect Theory.

(E) Macroeconomics, Monetary Economics: (ban) Banking, (cba) Central Banking, (dge) Dynamic General Equilibrium, (eff) Efficiency and Productivity, (gro) Economic Growth, (mac) Macroeconomics, (mon) Monetary Economics, (opm) Open Economy Macroeconomics, (pay) Payment Systems and Financial Technology.

(F) International Economics: (ifn) International Finance, (int) International Trade.

(G) Financial Economics: (cfn) Corporate Finance, (fdg) Financial Development and Growth, (fin) Finance, (fle) Financial Literacy and Education, (fmk) Financial Markets, (ias) Insurance Economics, (mfd) Microfinance, (mst) Market Microstructure, (ppm) Project, Program and Portfolio Management, (rmg) Risk Management.

(H) Public Economics: (pbe) Public Economics, (pub) Public Finance.

(I) Health, Education, Welfare: (edu) Education, (hea) Health Economics.

(J) Labor, Demographic Economics: (age) Economics of Ageing, (dem) Demographic Economics, (gen) Gender, (hap) Economics of Happiness, (hrm) Human Capital and Human Resource Management, (lab) Labour Economics, (lma) Labor Markets—Supply, Demand, and Wages, (ltv) Unemployment, Inequality and Poverty, (mig) Economics of Human Migration.

(K) Law and Economics: (law) Law and Economics.

(L) Industrial Organization: (com) Industrial Competition, (ent) Entrepreneurship, (ind) Industrial Organization, (nps) Nonprofit & Public Sector, (reg) Regulation, (tid) Technology and Industrial Dynamics.

(M) Business Administration & Business Economics, Marketing, Accounting, Personnel Economics: (acc) Accounting and Auditing, (bec) Business Economics, (cse) Economics of Strategic Management, (his) Business, Economic and Financial History, (mkt) Marketing, (sbm) Small Business Management,

(O) Economic Development, Innovation, Technological Change, Growth: (afr) Africa, (ara) Middle East & North Africa, (cna) China, (cis) Confederation of Independent States, (cwa) Central & Western Asia, (dev) Development, (eec) European Economics, (eur) Microeconomic European Issues, (ino) Innovation, (iue) Informal and Underground Economics, (lam) Central & South America, (sea) South East Asia, (tra) Transition Economics.

(Q) Agricultural and Natural Resource Economics, Environmental & Ecological Economics: (agr) Agricultural Economics, (ene) Energy Economics, (env) Environmental Economics, (res) Resource Economics.

(R) Urban, Rural, Regional, Real Estate, Transportation Economics: (geo) Economic Geography, (tre) Transport Economics, (ure) Urban and Real Estate Economics.

(Z) Other Special Topics: (cul) Cultural Economics, (ger) German Papers, (ict) Information and Communication Technologies, (spo) Sports and Economics, (tur) Tourism Economics.

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