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Network Effects in Knowledge Creation: Evidence from Academia

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Abstract

This paper makes use of a sample of articles published between 1999 and 2013 by economists affiliated in Portuguese institutions to examine the impact of co-authorship over the quality of academic research. We build a unique database to characterize the role played by distinct affiliations and educational backgrounds on this process, while controlling for experience and individual quality levels. Mentoring relations are identified as one possible source of negative bias on the measurement of teamwork productivity, which we proxy for and quantify here for the first time. The empirical results also suggest that co-authorship across domestic institutions does not carry any significant impact on research quality, but international collaboration enhances it. A doctorate earned abroad is shown to directly improve publication outcomes, besides making it easier to establish partnerships across frontiers. These findings underscore the importance of accessing external knowledge networks in academia, offering relevant policy insights for a large number of small and less developed countries.

JEL classification: A11; J44; I23
Keywords: Knowledge Networks; Co-Authorship, Academic Productivity.

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1. Introduction

The incidence of collaboration among researchers has steadily increased. Wuchty *et al.* (2007) evaluate 19.9 million papers and 2.1 million patents over a span of five decades to observe that teams have grown in relevance and now come to dominate solo authors across nearly all scientific areas. This rising trend is also evident within the field of economics. In 1963, only 16.3% of the articles published in the American Economic Review, Journal of Political Economy and Quarterly Journal of Economics involved more than one author. By 2011, this figure had climbed to 79.6% (Hamermesh, 2013). Similarly, the proportion of papers listed in EconLit and written by more than one author rose from 24.7% in the 1970s to 62.7% in 2011 (Ductor, 2014).

This paper adds to a growing body of literature on the dynamics of academic collaboration by examining the research output of economists affiliated with Portuguese institutions between 1999 and 2013. We explore different empirical sources to build a unique dataset characterizing both publications and the educational background of authors. This is used to answer two main questions. First, do co-authorships enhance productivity as measured by the quality of publications? Second, how is this effect conditioned by multiple characteristics of the researchers and their collaborators, namely geographical affiliation, experience, quality and education? In particular, do international ties enhance the value of research? We approach these questions using a multivariate regression framework applied to a small and less developed academic structure. This last point is worth special mention, given that many papers in this literature have failed to address the specific challenges faced by less productive countries, over-weighting instead their samples with researchers located in more developed nations.

Understanding the relative merits of alternative knowledge networks is of the utmost importance. At the micro level, research productivity is a driving force in academic progression and a commonly used indicator to assess the eligibility for grants and public funding opportunities. From a macro perspective, this characterization is useful in designing more efficient policies to promote scientific production. This is naturally more relevant when applied to lagging organizations, illustrated by the Portuguese example studied here. As Guimarães (2002) points out, despite an upward trend in overall scientific production, the research productivity of Portuguese universities has remained low. For instance, none of them currently figure in the top 100 Economics departments identified by Tilburg University, based on academic output from 2008 to 2012. Similarly, no Portuguese higher education institution shows in the top 350 of the Times Higher Education World University Rankings for the period 2014-2015.

Our findings add important insights to the mechanism of knowledge production. We observe that relations traditionally marked by a strong mentoring component, such as those where at least one of the co-authors has not yet earned a graduate degree, can negatively bias productivity estimates, something that has not been considered or quantified in previous studies. Once this is accounted for, international collaborations yield on average considerable gains on a journal's impact factor, even under identical levels of experience and similar authors quality, while joint work within the same institution does not display any significant effect on research outcomes. This argument extends also to the educational background of researchers. A doctorate obtained abroad is shown to increase the quality of publications, everything else constant. All these results

suggest the presence of external network effects that may go beyond the intrinsic worth of each collaborator. We verify as well that a journal's impact factor is the primary determinant of subsequent citation numbers. Co-authored articles can still earn a higher volume of citations within the same journal, but only provided that they are empirical.

The rest of the paper is organized as follows. Section 2 presents an overview of the related literature on academic co-authorship and its impact on productivity. Section 3 presents the data and descriptive statistics. Section 4 discusses the estimation framework and its results. Finally, section 5 concludes.

2. Related Literature

Productive collaboration can take many forms that go beyond joint publication. As a simple illustration, Laband and Tollison (2000) measure the value of informal comments offered by colleagues to find that their acknowledgment in title footnotes raises the estimated average citations of a paper by 42%. Notwithstanding, the focus on co-authorship data is pervasive in the literature. Katz and Martin (1997) identify several advantages in this methodological approach, namely its verifiability and invariance, data availability and ease of measurement. It might be argued that such properties also enable publication records to play a key role in the reward structure for academics, either in terms of promotions or raises. Hamermesh *et al.* (1982) use a sample of 148 full professors of economics to show that citations, interpreted as a proxy for research quality, are a major determinant of salary differences. After controlling for experience, their impact surpasses that of the number of published articles. This idea is also confirmed by Sauer (1988) though with distinct marginal effects for sole and co-authored papers. The return on wages from a joint publication with n authors is estimated to be approximately $1/n$ times that of a single-authored article. Diamond (1986) assumes that departments value the quantity and quality of a faculty member's research and posits these characteristics to be correlated with citation numbers as well. From here, he calculates that the marginal value of a citation (when its level is zero) lies between $50 and $1,300 (in 1984 dollars) depending on the discipline. This figure tends to decline, however, as the number of citations increases. The quality of the stock of publications, along with network effects, is also shown by Combes *et al.* (2008) to be positively and significantly related to the probability of successful hiring of economics professors in France.

It is then important to assess what the real value of co-authorship is regarding academic performance. Different factors have been suggested in the literature to explain its rising prevalence. For instance, Gordon (1980) suggests that co-authoring affords new opportunities for cross-checking results, enabling internal refereeing before the actual submission occurs. McDowell and Melvin (1983) argue that as knowledge grows (proxied by the total number of articles published in economics) the efficiencies of specialization become more pronounced. The division of labor entailed by co-authorship allows researchers to combine distinct skills in more productive ways. Barnett *et al.* (1988) confirm this idea empirically, among a wider range of hypotheses. Their evidence suggests that higher opportunity costs for time may also require formal modes of collaboration, beyond simple acknowledgment notes, in order to elicit the required effort for a thorough review of papers. In addition, they show that co-authorship may be used to

diversify against the risk of rejection and to cope with the random component of the editorial review process by increasing the number of papers submitted within a given time period. Hudson (1996) points out that the growth observed in the number of scientists, along with technological developments reducing communication costs, enhances the likelihood of finding suitable collaborators. He also links a higher incidence of joint work to the increasingly technical nature of the discipline, on both of its theoretical and quantitative dimensions. Laband and Tollinson (2000) uncover empirical support for this idea by verifying that the probability under which an economics paper is co-authored is an increasing function of the number of equations, tables and figures it contains. Along the same lines, Acedo *et al.* (2006) verify that co-authorship is more prevalent in highly quantitative journals within the fields of management and organizational studies.

These observations lend support to the idea that collaboration may indeed lead to higher quality research than sole-authored work. Presser (1980) provides additional evidence in this respect by analyzing editorial decisions on papers submitted to a leading social psychology journal. More precisely, he notices that joint work is positively correlated with acceptance outcomes across multiple disciplines. A similar result is revealed by Gordon (1980) within a sample of submissions to a top astronomy journal between 1968 and 1974. Laband and Tollison (2000) find also that co-authored economics papers are more likely to be accepted for publication, signaling their added value, although their inference is limited to a set of articles submitted to the Journal of Political Economy over a five year period. From a different point of view, Chung *et al.* (2009) note that co-authored articles published in prestigious finance journals are cited more often on average, though this relation disappears with purely theoretical papers. Significant knowledge spillovers arising out of co-authorship are identified by Azoulay *et al.* (2010) by measuring changes in the output of researchers linked by past work to eminent life scientists who die suddenly and unexpectedly. Results reveal a lasting 5% to 8% decrease in the level of their quality-adjusted publications following the loss of a superstar researcher. Endogenous network formation is addressed by Ductor (2014) to conclude that after controlling for this element, along with unobserved heterogeneity and time varying factors, collaboration leads to higher individual academic productivity. Finally, Bosquet and Combes (2013) study the micro determinants of publications and citations of French academic economists and find that the average number of authors per article has a negative impact on the quantity of published articles, but a positive effect on the average quality of publications, total publication scores and citation numbers. The latter holds even after controlling for journal quality. Among different hypotheses, this may suggest that when multiple authors present their results in a variety of settings, a broader diffusion of knowledge is enabled.

Nonetheless, the overall direction of these conclusions is far from consensual. Medoff (2003) fails to identify a positive effect of co-authorship over research quality, as measured by citation numbers, after controlling for article length, subject area, journal and author quality. Similarly, Acedo *et al.* (2006) verify that the importance of a scientific article in management, as captured by numbers of citations, depends primarily on the journal in which it is published, but not so much on whether it is sole or co-authored. This variable is at best weakly significant in only some types of journals. Hollis (2001) uses a sample of economists to show that, for a given individual, joint work is

associated with higher quality and frequency of publications, but once this output is discounted by the number of authors the net relationship becomes negative, suggesting a decline in total research. The same idea is confirmed by Lee and Bozeman (2005) within a broader range of fields, using a properly specified model to control for a wide variety of individual and personal characteristics identified by means of a survey. The explanations for these contrasting results are diverse. Hudson (1996) ventures that joint work may require a degree of compromise, discouraging risk taking and bounding creativity in favor of technical proficiency. Free-riding problems may occur as well, leading authors to reduce their contribution as the number of collaborators increases. Hollis (2001) points out that teamwork is subject to inefficiencies and potential diseconomies of scale due to effort duplication and coordination costs. Alternatively, Medoff (2003) observes that some co-authors may serve uniquely to access a data set or provide experience over the submission process, rather than making significant technical contributions. The motives prompting collaboration may indeed entail more than simple productivity considerations. Melin (2000) makes use of a survey to uncover that the most reported motive for teamwork (in 41% of the cases) is the special competence of a co-author. However, social reasons and supervising relations with students account for a sizable 30% of the responses. In this respect, Bozeman and Corley (2004) carry a more detailed econometric evaluation of mentoring strategies, noting that these are influenced by the tenure status of faculty, but not by gender or volume of grants. The net impact of teamwork remains, thus, open to discussion.

It may be the case that the full benefits of co-authoring require access to broader knowledge networks spread across geographical or institutional frontiers. Narin *et al*. (1991) analyze 400,000 papers published between 1977 and 1986 in a variety of scientific fields to observe that internationally co-authored articles were cited twice as highly as papers jointly written by scientists working in the same country at a single institution. Similarly, Katz and Hicks (1997) use a database of publications originating from UK based institutions and note that the highest impact work involves the participation of a foreign organization. Finally, Cardoso *et al.* (2010) verify that the increasing penetration of European authors in top Economics journals has been associated with a larger incidence of international co-authorships. These studies are however built around simple descriptive statistics or basic correlations. Frenken *et al.* (2010) carry a more comprehensive examination of eight science-based industries and verify that the citation impact of joint scientific publications increases with the spatial range of collaboration. The highest quality is observed at the international level, in particular when research occurs at the European scale or with the United States. One important caveat to bear in mind is that the previous results fail to control for the individual characteristics of researchers, whose differential quality may be the key productivity determinant, rather than institutional cross-fertilization per se. With this in mind, Hamermesh and Oster (2002) find that distant coauthoring by otherwise identical researchers, publishing articles of the same length and type in the same top economics journals, is actually less productive in terms of resulting citations numbers than geographically close relations. Chung *et al.* (2009) suggest that working with colleagues at the same institution may entail advantages in that communication is easier and monitoring against slacking behavior is potentially more effective. They find nonetheless that finance papers co-authored by researchers at the same institution are neither of higher nor lower quality

relative to other joint work, even in the absence of individual controls. Kim *et al.* (2009) add historical perspective to these arguments by showing that the positive knowledge externalities associated to sharing institutional affiliation with high quality colleagues declined in the 1980s and eventually vanished in the 1990s. The results are based on a database of economics and finance academics employed at top 25 universities in the United States and are explained by improvements in communication technologies, making long distance access possible at lower costs.

It must however be noted that most of these studies fail to identify the broader institutional context surrounding each researcher. The relative value of external knowledge networks is likely to depend as well on the characteristics of domestic institutions, which are quite dissimilar across countries. Our study takes one first step in addressing this by focusing uniquely on researchers located in an environment known for its less dense and dynamic academic structure. As shall be seen, the results thus obtained contrast with those suggested by Hamermesh and Oster (2002) and Chung *et al.* (2009).

3. Data and Descriptive Statistics

The primary information used in this paper is drawn from the Scopus database, which includes references on approximately 20,000 peer-reviewed journals, from more than 5,000 international publishers. By comparison with alternative sources, like the Social Sciences Citation Index, the coverage is broader, comprising as well a wider range of non-English language publications that can be expected to bear some weight in our target sample. Our analysis is restricted to articles and reviews published between 1999 and 2013 by authors affiliated to a Portuguese institution, within the subject areas of economics, econometrics and finance. Comments or corrections are excluded from our study. These criteria yield a total of 2,002 documents, each of which features information on the corresponding journal, number of pages, identity of authors and their affiliations. Complementary data on their educational background was collected by examining publicly available curriculum vitae and biographies, allowing us to record the highest degree held, the date it was conferred and the institution that granted it. This covers more than 95% of the authors in our sample. It also enabled us to identify and discriminate all cases where different researchers share identical surnames and first initials.

Table 1 presents basic summary statistics for our data. Co-authored work entails on average more pages, earns more citations and is published in journals with a higher impact factor, measured here by the corresponding SCImago Journal Rank (SJR). The distribution underlying many of these variables is nonetheless skewed, as made evident by their median values. Approximately 25% of the articles have received no citations at all. This last value excludes publications recorded in 2012 and 2013, which might be argued to be too recent for appropriate dissemination to have yet occurred. We do not have access to age information, so we use instead the average number of years since PhD to proxy for experience and assign it a value of zero whenever the author is known to lack a doctorate. This should not entail major distortions given that an overwhelming majority of the 2144 individual authors in our sample hold a PhD degree or are in the process of obtaining one, as illustrated by Figure 1. Moreover, only a negligible number of articles (1.4%) does not involve the participation of at least one PhD holding author.

TABLE 1. Summary Statistics

Single Authored Papers	*Mean*	*Median*	*Std. Dev.*	*Min*	*Max*	*Observations*
Number of pages	16.578	15	9.261	2	55	533
Citations per year *	0.830	0.286	1.935	0	31	427
SJR impact factor **	0.764	0.472	0.923	0.1	8.564	507
Avg. years since PhD **	6.921	6	5.802	0	34	531
Co-Authored Papers						
Number of authors	2.776	2	2.264	2	51	1469
Number of pages	17.569	17	8.760	2	77	1469
Citations per year *	1.492	0.667	3.190	0	64	976
SJR impact factor **	1.145	0.653	1.634	0.1	18.555	1426
Avg. years since PhD **	9.954	9.333	5.362	0	38	1379

* excludes self-citations and papers published in 2012 and 2013
** this value is not available for some journals/authors in some years

The average experience statistic we obtain may still hide substantial variance within research projects. With that in mind, we present in Table 2 the relative incidence of different experience ranges observed in the subset of co-authored papers. We see that joint articles involving only less experienced researchers (five or less years) account for a relatively small share of their output. Most projects entail the participation of at least one senior team member with six or more years of experience. This suggests one possible channel through which collaboration may come to yield individual productivity gains. It can be observed as well that a sizable 27.1% of total co-authorships include authors with either no PhD or a PhD granted the year the article is published (that is, with experience

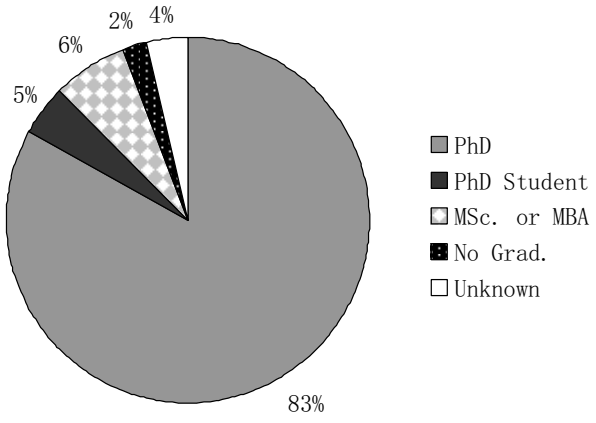

FIGURE 1. Authors Graduate Education

TABLE 2. Experience Range Among Co-Authors

		Maximum Experience							
	Years	*0*	*1 - 5*	*6 - 10*	*11 - 15*	*16 - 20*	*21 - 25*	*> 25*	*Total*
Minimum Experience	*0*	1.0	3.0	6.6	6.0	5.4	2.3	2.7	27.1
	1 - 5		3.6	10.9	6.6	7.6	3.6	5.3	37.6
	6 - 10			6.5	7.1	6.3	2.9	2.8	25.6
	11 - 15				2.0	3.2	1.2	0.8	7.2
	16 - 20					0.6	0.7	0.7	1.9
	21 - 25						0.0	0.5	0.5
	> 25							0.1	0.1
	Total	1.0	6.6	24.1	21.7	23.0	10.6	12.9	100.0

All values expressed in percentage.

equal to zero). There may be a mentoring component to many of these cases and it is noteworthy that the most experienced partner fits more often in the 6 to 10 year experience range, shortly after tenure decisions have typically been made.

A count of the number of articles published shows us that the volume of academic production arising out of Portuguese institutions has steadily increased, at an average rate of more than 17% a year. A large fraction of this work displays a collaborative nature. The average number of authors per article is 2.3. Their frequency distribution can be found in Figure 2, indicating that most teams (65%) see their size range from two to three elements. This profile has also evolved over time. The correlation coefficient between the number of authors and the number of years since each paper was published is negative

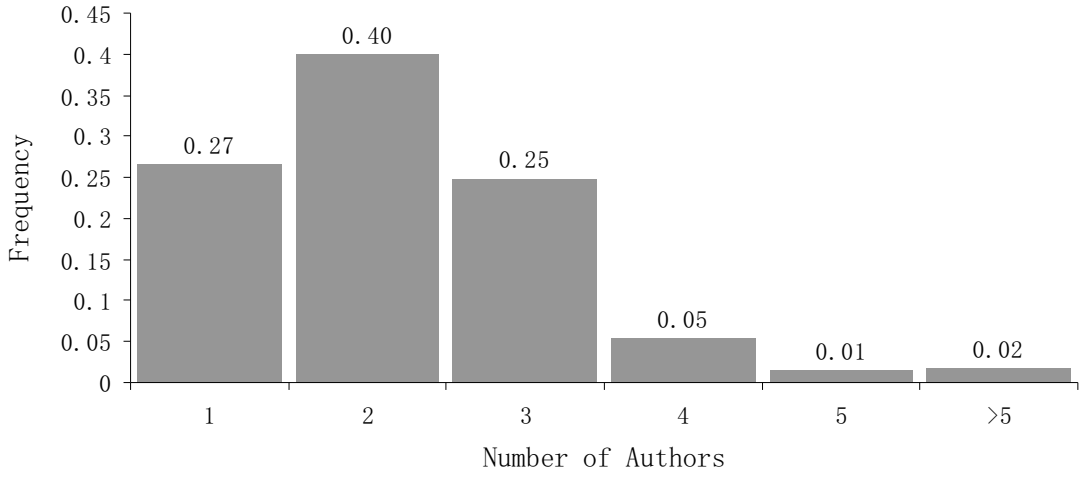

FIGURE 2. Distribution of Co-Authorship Intensity

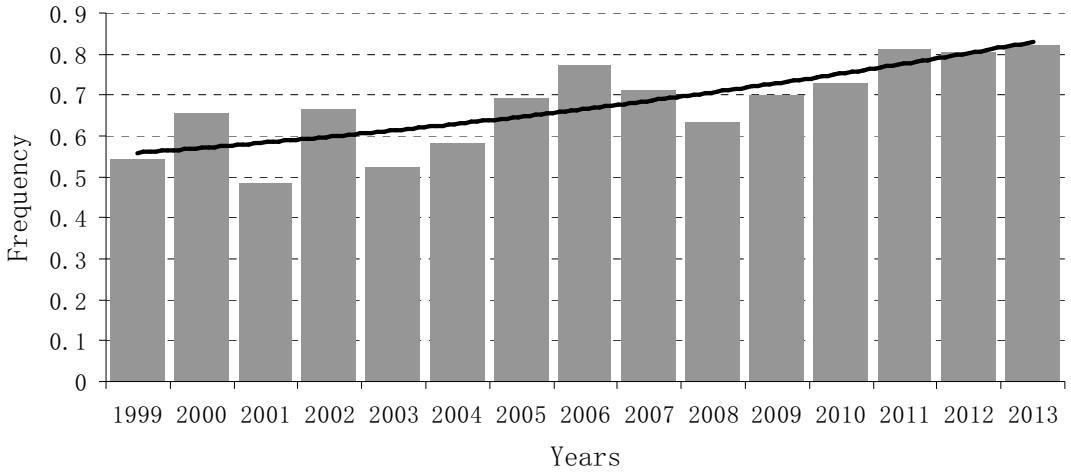

FIGURE 3. Co-Authorship Incidence

and equal to -0.214 (excluding articles with more than five authors to avoid distortions from outliers). In other words, more recent papers tend to have more authors on average.

The simple incidence of co-authored research has also risen in the sample interval (see Figure 3). These partnerships have a strong international component, as highlighted by Figure 4, which is not surprising given the relatively low number of Portuguese academic institutions. At the same time, domestic connections show evidence of gains in importance over the last decade, accounting for 54.2% of all collaborations in 2013, as opposed to 28.2% in 2004. As a reference point, similar values observed for all research institutions in Europe and the United States in 2011 stood at 58.6% and 64.7%, respectively (Elsevier, 2013). Increased research activity, as noted before, may create new opportunities for the development of local knowledge networks. The geographical distribution of external co-authors is illustrated by Figure 5. Where multiple affiliations

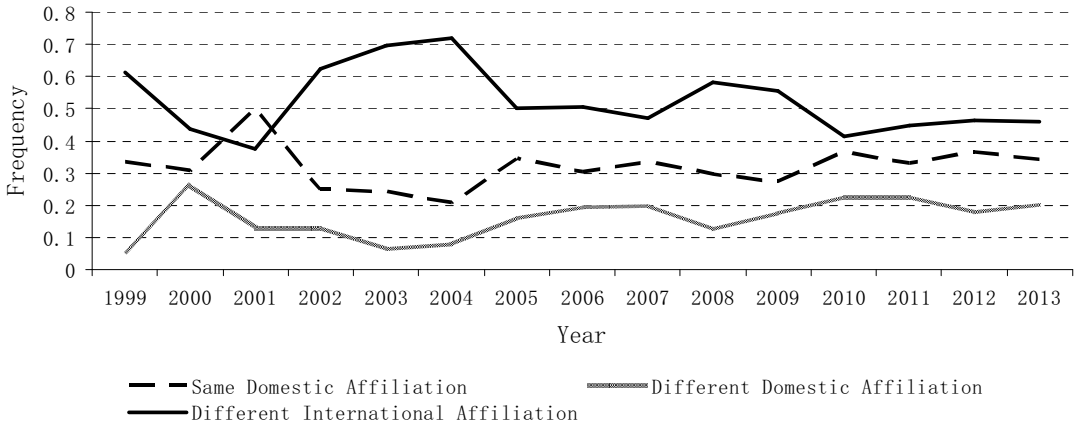

FIGURE 4. Co-Authors Affiliations

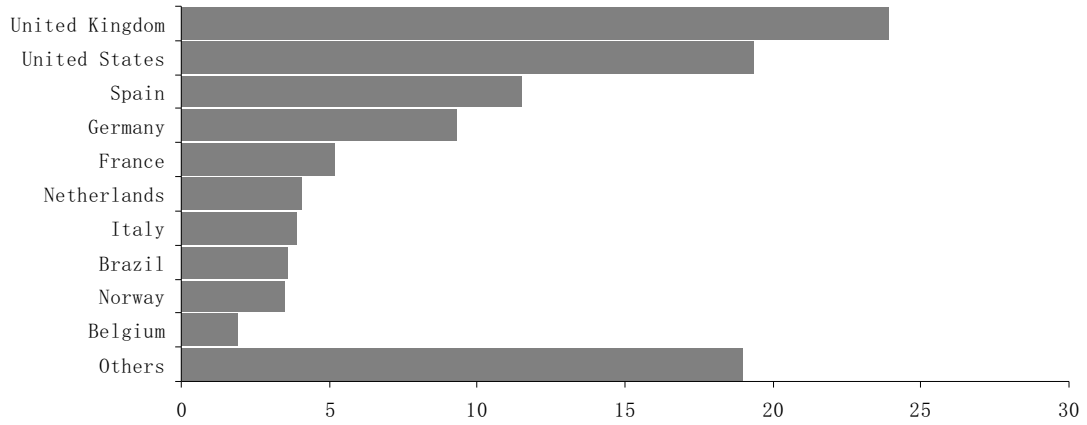

FIGURE 5. Co-Authors International Affiliations (in Percentage)

are reported, we register here only the first one. There is a high incidence of associations with the United States, but in broader terms collaborations across the European space are still prevalent, accounting for more than 70% of the total number of links established with researchers abroad. Proximity and language may also facilitate some of these ties, in light of the strong institutional presence of countries like Spain and, to a lesser degree, Brazil.

Table 3 presents correlation coefficients between different variables used in our study. Longer papers and a larger number of authors are marginally associated with more average citations and a higher journal impact factor, but the correlations are nonetheless weak. A moderate positive relationship emerges between citation counts and a journal's impact factor, making it appropriate to test the mutual robustness of each of these alternative measures when assessing research quality outcomes. Ultimately, a clearer picture of the potential interactions suggested by this data, with all the necessary controls for individual heterogeneity, can only be attained through multivariable regression analysis, which we proceed to describe and develop in the next section.

TABLE 3. Correlation Matrix

	(1)	(2)	(3)	(4)	(5)
Number of pages (1)	1				
Number of authors (2)	0.03	1			
Citations per year † (3)	0.12 ***	0.09 **	1		
SJR impact factor (4)	0.20 ***	0.08 ***	0.39 ***	1	
Avg. years since PhD (5)	0.02	0.11 ***	0.04	0.09 ***	1

† excludes self-citations and papers published in 2012 and 2013
*, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

4. Empirical Analysis

4.1 Econometric Specification and Variables

The baseline equation we use to test our hypotheses is expressed as follows:

$$Y_{i,t} = \beta_0 + \beta_1 CA_{i,t} + \beta_2 AF_{i,t} \times CA_{i,t} + \beta_3 EXP_{i,t} + \beta_4 EXP_{i,t}^2 + \beta_5 AQ_{i,t} + \phi_t + \mu_{i,t}, \quad (1)$$

where $\{\beta_0, ..., \beta_5, \phi_t\}$ are parameters to be estimated using ordinary least squares and $\mu_{i,t}$ is a random disturbance term.

Our dependent variable $Y_{i,t}$ is a measure of the quality associated to each article *i* published in year *t*. We assume here that the journal in which the paper is published can be used to proxy for this productivity dimension. Laband and Piette (1994) have developed a well known journal ranking based on weighted citation numbers per article, but its scope is too limited for our needs, covering approximately just one fourth of all the journals featured in our sample. Therefore, we use instead the publicly available SCImago Journal Rank (SJR) indicator which also weights the number of citations received by the importance of the academic journal they come from. The construction of this impact factor draws on information contained in the Scopus database, thus ensuring a broad and detailed coverage of the journals included in our study across different years.

The length of the article is frequently reported in the literature as one added indicator of research quality. The link between these variables is econometrically supported by Piette and Ross (1992) when the latter is measured by citation numbers. This is consistent with the assertion set forth by Sauer (1988) that journal editors attempt to maximize value in allocating limited space within each edition. It may also be the case that more complex and original pieces of research come to require greater exposition than less substantive research. Differences in layout, formatting and scope across journals prevent us from using a simple page count to gauge this variable, so we follow Bosquet and Combes (2013) and Ductor (2014) in calculating the ratio of the number of pages of each article relative to the average number of pages of all the articles published in the respective journal in the same year. We exclude letters to the editor, comments, replies, corrections, introductions to special issues or any other atypical pieces in determining this value.

Our composite measure of research quality can therefore be presented as

$$Y_{i,j,t} = \log[SJR_{j,t} \times (P_i / \bar{P}_{j,t})], \quad (2)$$

where the quality of an article *i*, published in journal *j* and in year *t*, depends on the SJR impact factor of that journal in the specified year and the number of pages of the article relative to the average number of pages in the journal in each year. Since the distribution of the resulting values is considerably skewed, a log transformation is applied to this variable in order to minimize any distortion arising out of some extremely high quality papers on our estimates.

Our main variable of interest, CA, takes a value of 1 when the paper is co-authored and 0 when it is single-authored. The hypothesis that co-authoring leads to productivity gains requires the coefficient associated to this variable to be positive. We

add one interaction term, AF, which takes a value of 1 if at least one of the co-authors reports an exclusively different affiliation and 0 when the same institutional affiliation is shared by everyone. We exclude all observations featuring more than five co-authors in order to limit the effect of outliers. This amounts to thirty four articles, many of which cover very specific subfields characterized by cross-disciplinary work with limited economics content (for instance, nine of them are featured in the journal *Marine Policy*).

Lee and Bozeman (2005) note that senior researchers have had more time to develop their human capital and build up professional networks. This might erroneously assign productive benefits to a co-authorship arrangement in the absence of a proper control for experience. We evaluate life-cycle effects through the variable EXP which measures the number of years since the PhD of each author was granted. In cases where he does not hold this degree or an equivalent one, we assign a value of zero to this measure. If multiple co-authors are present, we determine the simple average over their individual scores. We also introduce the square of this statistic to allow for the possibility that experience may carry a non-linear impact on productivity. The expected sign of these coefficients is not immediately clear, though. Hansen *et al.* (1978) identify a positive and concave relation between the length of experience and a simple count of journal publications for academic economists. This result is rejected by Levin and Stephan (1991) across six fields of physics and earth sciences where a negative link between age and different research output measures is uncovered. They argue that stronger financial incentives for scientists to engage in research and build up human capital are more likely to arise earlier in their careers. Using a sample of economists, Hollis (2001) identifies as well declining output quality as years since graduation increase.

The variable AQ in our regression is used to control for the quality of authors. Higher ability individuals may be more sought after by potential collaborators, which could again distort the measured impact of co-authorship. With this in mind, Laband and Tollison (2000) and Medoff (2003) count the cumulative stock of citations received by authors over a time interval preceding the publication of the paper. We adopt the same strategy, excluding from our computation all self-citations and restricting our analysis to the five years prior to each observation date. This reduces the volume of citations drawn from older work, likely subject to higher technical depreciation and further removed from the current knowledge frontier. Given the large range of this variable, we adopt here its logarithm. At the time this data was collected, Scopus only reported citations from 1996 onwards, so the earliest observations we may use refer to the year 2001. Nonetheless, only 67 articles are lost on this account.

Finally, our regression model includes dummies (ϕ_t) for each year in the sample. This aims to capture possible inter-temporal differences in publishing constraints, arising out of changes in the number of available journals or the number of competing researchers. It may also reflect evolving degrees of efficiency in communication technologies, affecting the productivity out of long distance collaboration.

4.2 Results

The estimated coefficients for our initial regressions are reported in Table 4. As expected, the quality of authors is clearly and positively related to the quality of their

Table 4. Baseline Regressions

	Regression				
Variable	(1)	(2)	(3)	(4)	(5)
EXP	0.0102	0.0111	0.0138	0.0166	0.0127
	(0.0123)	(0.0123)	(0.0122)	(0.0123)	(0.0123)
EXP^2	-0.00109*	-0.00113*	-0.00126**	-0.00143**	-0.00121**
	(0.000439)	(0.000441)	(0.000435)	(0.000447)	(0.000444)
AQ	0.207***	0.196***	0.175***	0.168***	0.182***
	(0.0153)	(0.0158)	(0.0170)	(0.0170)	(0.0168)
CA	-0.0908	-0.196**	-0.206**	-0.199**	-0.163*
	(0.0619)	(0.0672)	(0.0676)	(0.0675)	(0.0668)
CA x AF		0.196**			
		(0.0599)			
CA x AF-D			0.0644	0.0632	0.0150
			(0.0728)	(0.0729)	(0.0711)
CA x AF-F			0.330***	0.256***	
			(0.0715)	(0.0727)	
CA x AF-US				0.600***	
				(0.114)	
CA x AF-F (%)					0.472***
					(0.125)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	1,734	1,734	1,734	1734	1,734
R-squared	0.134	0.139	0.146	0.154	0.143

Notes: the dependent variable is Y. Robust standard errors in parenthesis. *, **, *** significant at the 0.05, 0.01 and 0.001 levels, respectively. In regression (4), the variable CA x AF-F excludes cases where at least one author is affiliated in the United States.

research. Regression (1) would seem to suggest the absence of a statistically significant link between co-authorship and paper quality, but this result can be misleading. Indeed, regression (2) indicates that co-authorship yields a negative impact on our dependent variable when authors are affiliated in the same institution, but not necessarily so otherwise. To further explore this hypothesis, we refine the role of affiliation by disaggregating the original dummy into two possible categories. AF-D takes a value of 1

when different domestic affiliations are reported by the co-authors, whereas AF-F assumes a value of 1 if at least one of the researchers presents an exclusively foreign affiliation. The omitted category refers to collaborations observed within the same institution. We complement this approach in regression (4) by introducing one country specific dummy, AF-US. As noted by Cardoso *et al.* (2010), the United States account for a share of more than 70% of the articles published in top Economics journals. They also display a singular concentration of highly ranked institutions connected by dense knowledge networks, so our variable takes a value of 1 when there is at least one affiliation in this country. The results indicate that domestic co-authorships still decrease the quality of the research outcome, but that is no longer the case with international collaborations. In particular, it is not possible to reject the hypothesis that the combined value of the coefficients attached to variables CA and CA x AF-F is positive. When evaluated at the sample mean, replacing a domestic co-author in the same institution with a foreign-affiliated one entails a gain of 33% in the adjusted impact factor of the journal the article is published in. The value increases to 60% when the new collaborator is located in the United States.[1] These productivity outcomes contrast with the evidence provided by Hamermesh and Oster (2002) and Chung *et al.* (2009). Alternatively, we also measure the fraction of authors within a research team who are affiliated outside the country, denoting this variable by AF-F (%). Regression (5) confirms that the higher the international content of the collaboration, the more the outcome improves.

We now introduce additional controls to our baseline regression. Recall that the variable EXP takes a value of zero regardless of whether the author obtained his PhD in the same year as the publication or holds no PhD at all. Hence, we isolate the impact of the second case by defining a dummy variable NO-PHD which takes a value of 1 when at least one author lacks this degree. This type of collaboration is likely to involve a much stronger mentoring dimension, impacting the objective function of the main researcher(s). It is not surprising that research quality drops in that event. More interestingly, the magnitude of the negative coefficient associated to co-authorship within a common institution falls to the point where it may no longer be rejected that it carries no effect, as illustrated by regressions (1) and (5) in Table 5. Notice that approximately 46% of these links are established within the same university and 72% of them are strictly domestic. In the same way, the effect of international collaboration relative to single authored research is now significantly positive. This conclusion is noteworthy in that it holds even after controlling for identical levels of authors' quality. This suggests that, from the point of view of a small country, access to knowledge networks centered on international institutions plays a key role in enhancing academic productivity.

We also characterize in more detail the educational background of researchers affiliated in Portugal by using a set of dummy variables to identify where they earned their graduate degree. Accordingly, PHD-F takes a value of 1 when at least one of these authors receives his PhD from a foreign institution. The omitted category refers to doctorates obtained within Portugal. Similarly, PHD-US identifies the presence of at least one domestically affiliated author with a PhD earned in the United States. These variables carry a strong impact on research quality, as made clear by Table 5. An author who

[1] As a reference point, a similar regression estimates the average gain derived from a replacing a domestic collaborator with one affiliated in the United Kingdom to be 42.7%. The coefficients associated with Spain, Germany or France are not statistically significant.

Table 5. Additional Determinants of Research Productivity

	Regression				
Variable	(1)	(2)	(3)	(4)	(5)
EXP	-0.0139	0.00105	-0.00463	0.0101	-0.0234
	(0.0131)	(0.0118)	(0.0118)	(0.0124)	(0.0127)
EXP^2	-0.000527	-0.000909*	-0.000817	-0.00123**	-0.000329
	(0.000454)	(0.000415)	(0.000421)	(0.000447)	(0.000441)
AQ	0.186***	0.170***	0.166***	0.177***	0.180***
	(0.0169)	(0.0167)	(0.0166)	(0.0169)	(0.0166)
CA	-0.0848	-0.228***	-0.232***	-0.152	-0.0737
	(0.0706)	(0.0661)	(0.0655)	(0.0901)	(0.0902)
CA x AF-D	0.0661	0.0408	0.0102	0.0563	0.0360
	(0.0716)	(0.0717)	(0.0714)	(0.0730)	(0.0710)
CA x AF-F	0.264***	0.317***	0.332***	0.317***	0.255***
	(0.0713)	(0.0703)	(0.0692)	(0.0711)	(0.0699)
NO-PHD	-0.394***				-0.306***
	(0.0634)				(0.0636)
PHD-F		0.473***	0.341***		0.455***
		(0.0485)	(0.0504)		(0.0479)
PHD-US			0.775***		
			(0.0709)		
EMP				-0.267**	-0.251**
				(0.0882)	(0.0841)
CA x EMP				0.0316	0.0143
				(0.106)	(0.102)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	1,734	1734	1,734	1,725	1,725
R-squared	0.161	0.190	0.212	0.158	0.212

Notes: the dependent variable is Y. Robust standard errors in parenthesis. *, **, *** significant at the 0.05, 0.01 and 0.001 levels, respectively. In regression (2), the variable PhD-F excludes cases where an author affiliated in Portugal obtained his PhD in the United States.

TABLE 6. International Graduate Degrees and Co-Authorships

	(1)	(2)	(3)
Total Papers	744	753	389
Fraction of Co-Authored Papers	65.1%	74.4%	79.9%
Fraction of Co-Authored Papers with Foreign Affiliated Authors	28.4%	37.6%	38.6%
Fraction of Co-Authored Papers with Authors Affiliated in the US	7.0%	7.2%	27.5%

(1) the paper includes only authors affiliated in Portugal and with a PhD earned in Portugal;
(2) the paper includes at least one author affiliated in Portugal with a PhD earned abroad, other than the United States;
(3) the paper includes at least one author affiliated in Portugal with a PhD earned in the United States.

receives his graduate degree in the United States improves the adjusted impact factor of the journal he publishes in by roughly 77.5% relative to similarly experienced and cited researchers who did not study abroad. Naturally, there may remain some degree of self-selection in educational choices, based on unobservable quality differences, which we cannot properly evaluate with the available data. In any case, these estimates are likely to undervalue the actual benefits of doing graduate studies abroad. Table 6 highlights that such researchers can establish partnerships more easily, in particular when they span different countries. For instance, earning a degree in the United States increases access to its knowledge networks through co-authorship by almost four times. As noted before, this is one important channel leading to large qualitative gains. These overall results are consistent with evidence gathered by Jonkers and Tijssen (2008) and Jonkers and Cruz-Castro (2013) on the productivity of Chinese and Argentinean molecular life scientists who return to their native environment after a foreign work or graduate study experience.

Finally, we examine the sensitivity of our results to the theoretical or empirical nature of the article. We skim each paper to create a dummy variable EMP_i which takes a value of 1 when paper *i* contains any empirical component and 0 otherwise. This generally includes analyses where data needs to be handled by means of econometric regression or any other statistical instrument. The impact on the dependent variable is significant and negative (see Table 5). In other words, purely theoretical papers fare on average better regarding the quality of the journal they are published in. This result is not different for joint work or single authored papers. It must be noted, however, that the incidence of co-authorship is considerably higher for empirical papers relative to theoretical ones (80.5% vs. 63.3%). It is possible that collaboration is required for many of these data based projects to be carried out altogether, which configures one indirect productivity gain.

4.3 Robustness

We test here the robustness of our results by exploring alternative measurements for both independent and dependent variables. We start by examining the quality of authors. It could be argued that the added value of co-authorship for two researchers

featuring identical citation levels is more appropriately measured against the output of a single author with a similar citation stock, everything else identical, rather than twice that number as the initial formulation supposes. Hence, AQ-A_i averages the five year count of citations across the co-authors of paper *i* instead of adding them up. The variable AQ-W_i weights citations for each past article by the number of co-authors under the presumption that they do not deserve full credit for joint work. This also avoids double counting problems that might arise if the same group of co-authors previously worked together. The ensuing values are tallied up as before, while the variable AQ-WA_i averages them. We test as well a simpler aggregation mechanism, limiting the combined quality of all co-authors to their maximum individual number of citations, denoted by AQ-MAX_i. Finally, we average individual citations with reference to the number of articles published by each author up to the observation year and then add up those values to obtain variable AQ-PA_i. The estimation results are reported in Table A1 in Appendix. They are fundamentally identical to those obtained before. The magnitude of the coefficient associated with co-authorship (CA) becomes larger and positive when average measures of author quality are used, but not yet statistically significant.

The extent of co-authorship can also be examined in more detail. With that in mind, we define a variable AUT_i to measure the number of authors for each paper *i* and to capture in this way the scope of intellectual collaboration. Table A2 in Appendix suggests that increasing team size across international boundaries is better than undergoing a similar change within domestic institutions. It is however not possible to reject the hypothesis that the overall effect on paper quality (obtained from combining the coefficients of variables AUT and AUT x AF-F) is equal to zero. Alternatively, we create individual dummies for each possible number of co-authors, labeled CA_2 through CA_5. Single authored papers are treated as the omitted category. This may enable a better understanding of how team size relates to potential scale economies or transaction costs imposed by added coordination and monitoring needs. We observe that international collaborations generate added productivity gains when the number of co-authors equals two or three. Beyond this, it is not possible to identify statistically significant effects from changing the affiliations of researchers, as made clear by Table A3 in Appendix. In all these cases, the coefficients of the main control variables remain virtually identical to those previously reported.

We turn now our attention to the dependent variable and consider alternative ways of assessing research quality. For the sake of a robustness check, we make our quality index the same as the SJR impact factor, that is, we forego any weighting by page numbers. The main conclusions obtained thus far are not affected by this. We also run our main regression without the top 1% values for the dependent variable in order to verify whether any of the results might be driven by a limited set of articles of unusually high quality. Once again, our results still hold in a similar way.[2]

One limitation in using impact factors is that these fail to capture potential quality differences within the same journal. A number of studies resort instead to citation counts as a measure of the scientific usefulness of the article. Its relevance within the research frontier may proxy for intrinsic quality, but this approach is not without problems. First, there is no distinction between negative and positive citations. Medoff (2003) addresses this criticism by pointing out that once an article is refuted, the number of citations it

[2] These results are available from the authors upon request.

earns naturally declines, minimizing possible distortions. Second, the journal where the citation is made is likely to influence its value, something we cannot control for here. Finally, academic papers tend to experience citation life-cycles. Liebowitz and Palmer (1988) observe in a sample of articles that citations rise for three years after publication, peak between the fourth and seventh years, and decline afterwards. A simple yearly average of citations collected by a paper may therefore be misleading in that it is prone to undervalue older pieces of research. One way to deal with this problem is to measure the total number of citations received over a fixed and sufficiently large period of time following the publication of the paper. Unfortunately, the temporal length of our sample, combined with the higher concentration of articles in later years, would imply an excessive loss of observations. Hence, we adapt instead a solution proposed by Chung *et al.* (2009) and inspired by literature studying the scientific value of patents. This entails deflating the number of years since publication by a given depreciation rate when computing the yearly average of citations, according to the formula

$$\mathrm{CIT_i} = \log\left[\frac{\text{Total number of citations}_\mathrm{i}}{\sum_{x=1}^{\mathrm{m}}(1-\delta)^{x-1}} + 1\right], \qquad (3)$$

where m is the number of years since publication and δ is a depreciation rate. Our citation count goes up to the end of 2014. We exclude self-citations and test different rates, namely 5%, 10%, 15% (a standard depreciation rate for patent citations) and 20%. The results they yield are not substantially different.

As Medoff (2003) points out, the number of citations is left censored at zero and ordinary least square estimates can be biased under such conditions. We observe a large clustering of observations at this lower bound (approximately one third of the sample) which may fail to capture additional variability in the latent quality levels of these articles. Therefore, we run our new regression using a Tobit maximum likelihood model. Observations from 2012 and 2013 are dropped, given that not enough time may have elapsed for them to be adequately cited. In addition to the controls described before, we add the length of the paper (PAGES) and the quality of the journal (SJR, logarithmized) to the set of explanatory variables, given that longer articles may contain more information that can be cited and better journals generate more exposure to papers.

The results presented in the first regression of Table 7 do not allow us to identify any significant effect from co-authoring or different affiliation modes on the number of citations once the impact factor of the journal where the paper is published is controlled for. This suggests that the benefits derived from collaboration are largely captured by the quality of the corresponding research outlet, which is a strong predictor of the volume of citations earned by a paper. Regression (1) in Table 7 also highlights that empirical papers are more heavily cited within similar quality journals, everything else constant. This effect is notably stronger when the article is co-authored. To the extent that joint research is sometimes discounted for the purpose of tenure evaluations or merit pay, we test the impact of our explanatory variables on a fractional count of citations, weighting these by the number of authors. The estimates presented in regression (2) attach now a statistically significant negative effect to co-authoring, which is not surprising given our previous observations.

Table 7. Regressions on Citations Counts

	Regression	
Variable	(1)	(2)
EXP	0.00433 (0.0109)	0.00259 (0.00897)
EXP^2	-0.000207 (0.000361)	-0.000123 (0.000296)
AQ	0.0476** (0.0157)	0.0269* (0.0122)
CA	-0.0829 (0.0821)	-0.286*** (0.0680)
CA x AF-D	0.139 (0.0745)	0.0917 (0.0556)
CA x AF-F	0.0221 (0.0629)	-0.0322 (0.0472)
PHD-F	-0.0642 (0.0448)	-0.0543 (0.0362)
NO-PHD	0.0665 (0.0586)	0.0155 (0.0439)
EMP	0.285*** (0.0774)	0.242*** (0.0725)
CA x EMP	0.191* (0.0922)	0.106 (0.0810)
PAGES	0.00448 (0.00253)	0.00418* (0.00211)
SJR	0.417*** (0.0258)	0.324*** (0.0216)
Year Fixed Effects	Yes	Yes
Observations	1,223	1,223
Pseudo R-squared	0.178	0.186

Notes: the dependent variable in regression (1) is CIT, using a 15% depreciation rate for citations. In regression (2), the dependent variable weights the number of citations by the number of co-authors. Robust standard errors in parenthesis. *, **, *** significant at the 0.05, 0.01 and 0.001 levels, respectively.

4.4 Potential Limitations

The empirical results presented in the previous section are robust across multiple specifications, but some potential limitations should still be addressed. Our sample of articles might conceivably display a selectivity problem if co-authorship also impacts whether a paper is published or not. A thorough test of this hypothesis would however require access to a complete list of paper submissions. At worst, the gains from collaboration we already identified may result underestimated.

We can also not rule out that unobservable quality differences subsist between authors. This may be more relevant when these researchers have just recently obtained their PhD and not enough time has gone by for them to build up a discriminating stock of individual citations. With this in mind, we run our regressions in more limited samples including only authors with a minimum experience level of five and ten years and the main conclusions regarding the relative value of different affiliation modes still hold.[3]

One other issue refers to the fact that joint work may be the product of endogenous choices depending themselves on the quality of research. Our database lacks the necessary information to develop adequate instruments for this, but it is not even straightforward that a given causality nexus should exist. It can be argued that higher impact and complex papers require complementary skills, thus making co-authoring likely, whereas lesser quality projects are more easily handled by single authors. On the other hand, it is equally possible that individuals may wish to fully appropriate better ideas, sharing instead those with less potential. Ultimately, Medoff (2003) points out that no compelling evidence can be gathered to sustain the hypothesis that high quality research is too difficult for one economist to do alone, justifying in this way the absence of instrumental variables from his study. The collaboration decision may indeed be driven by factors entirely unrelated to these. For instance, McDowell and Melvin (1983) observe that the proportion of co-authored articles relative to all written papers is negatively associated with the ratio of young to mid-career economists. This suggests that the former tend to work alone in the earlier stages of their career in order to build a brand name. As individuals gain more experience and develop professional networks, the opportunities for collaboration arise more naturally.

5. Discussion and Conclusions

This paper examined different possible links between academic productivity and co-authorship. Its findings provide useful guidance to promote further scientific advance, in particular within lagging research environments. The impact factor of the journals where articles are published can be increased by means of collaboration, but only when this spans institutions located in different countries. The higher the international content of the research team, the more stands to be gained. Earning a PhD abroad enhances as well the productivity of domestically affiliated researchers. Theoretical papers are published on average in more highly ranked journals, but they do not seem to benefit from collaboration. On the other hand, empirical work found in similar quality journals

[3] These results are available from the authors upon request.

earns more citations when it is the product of co-authorship. All these results hold under appropriate controls for experience and the quality of authors. In addition, they are robust to multiple alternative specifications required to aggregate citation stocks across different individuals. Access to external networks is therefore shown to be a key determinant of research outcomes. These seem to be most effective when centered in the United States, both through affiliation or as the source of graduate degrees.

Literature on social networks provides some insights on the way this academic mesh can evolve. For instance, Fafchamps *et al.* (2010) study the formation of research collaborations among economists over a twenty year period. These are found to be more likely when the distance between co-authors in a network of existing social ties is lower. The group of past team members is well suited to disclose information on ability and match quality, allowing individuals to economize on their search costs. This process is naturally cumulative and self-reinforcing. We present evidence that carrying graduate studies abroad opens up access to a more extensive set of foreign connections. While less developed academic structures often endure significant brain drain, specially after domestic researchers complete their degrees elsewhere, this may still be regarded as a unique opportunity to expand knowledge networks if links with the home institutions are nurtured and preserved. Under the same logic, supporting increased participation in international conferences, workshops or research centers becomes a more justified policy tool.

Our conclusions entail important methodological implications as well. The added value of international affiliations in the present sample holds after controlling for author quality. This suggests that the relative benefits of collaboration may be dependent on broader institutional characteristics surrounding each of the potential researchers in a way that goes beyond their own individual worth. We also find evidence that some types of collaboration may be used to promote mentoring opportunities, in which case research output is not necessarily optimized. This is mostly observed within domestic boundaries. Once the presence of co-authors lacking a doctorate is accounted for, estimates for the impact of joint work are naturally affected. Finally, we verify that the quality of a journal is the strongest predictor of the number of citations earned by a paper. Nonetheless, this control should not neglect the fact that a subset of co-authorship modes can enable publication in more highly ranked outlets, featuring broader readership and citation potential. This is not accounted for by Medoff (2003), for instance.

Future work may further validate the conclusions just described beyond the Portuguese case examined here. When institutional context matters, the lack of a critical mass of research capability enveloping domestic authors is likely to enhance the value of international collaboration, namely when this intersects key nodes of knowledge networks, like those found in the United States and the United Kingdom. This hypothesis is consistent with our evidence. Hence, interacting the marginal contribution of co-authorship with national measures of institutional quality across a broader sample of countries might also yield significant results. The data collection requirements for such a project go beyond the scope of this paper, but nonetheless point the direction for new research.

Appendix

Table A1. Robustness Checks: Alternative Measurements of Author Quality

	Regression				
Variable	(1)	(2)	(3)	(4)	(5)
CA	0.0122	-0.0340	0.0472	-0.0461	-0.0727
	(0.0688)	(0.0694)	(0.0686)	(0.0697)	(0.0699)
CA x AF-D	0.0399	0.0313	0.0356	0.0374	0.0317
	(0.0709)	(0.0711)	(0.0714)	(0.0711)	(0.0715)
CA x AF-F	0.271***	0.253***	0.279***	0.269***	0.300***
	(0.0692)	(0.0707)	(0.0699)	(0.0696)	(0.0667)
EXP	-0.0230	-0.0223	-0.0207	-0.0218	-0.0163
	(0.0127)	(0.0127)	(0.0126)	(0.0127)	(0.0123)
EXP^2	-0.000368	-0.000345	-0.000407	-0.000345	-0.000444
	(0.000438)	(0.000437)	(0.000434)	(0.000440)	(0.000427)
AQ-A	0.204***				
	(0.0190)				
AQ-W		0.197***			
		(0.0190)			
AQ-WA			0.222***		
			(0.0221)		
AQ-MAX				0.179***	
				(0.0170)	
AQ-PA					0.362***
					(0.0301)
Additional Controls	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	1,725	1,725	1,725	1,725	1725
R-squared	0.212	0.208	0.205	0.209	0.226

Notes: the dependent variable is Y. Robust standard errors in parenthesis. *, **, *** significant at the 0.05, 0.01 and 0.001 levels, respectively. Additional controls include EMP, NO-PhD and PhD-F.

Table A2. Robustness Checks (Cont'd)

Variable	
EXP	-0.0223 (0.0127)
EXP^2	-0.000362 (0.000444)
AQ	0.185*** (0.0170)
AUT	-0.0629 (0.0381)
AUT x AF-D	0.0108 (0.0276)
AUT x AF-F	0.0944*** (0.0264)
PHD-F	0.460*** (0.0485)
NO-PHD	-0.296*** (0.0658)
EMP	-0.237*** (0.0480)
Year Fixed Effects	Yes
Observations	1,725
R-squared	0.212

Notes: the dependent variable is Y. Robust standard errors in parenthesis. *, **, *** significant at the 0.05, 0.01 and 0.001 levels, respectively.

Table A3. Robustness Checks (Cont'd)

Variable	
CA_2	-0.0913 (0.0766)
CA_3	-0.00428 (0.103)
CA_4	-0.0134 (0.186)
CA_5	-0.483 (0.328)
CA_2 x AF-D	0.104 (0.0860)
CA_3 x AF-D	-0.0495 (0.147)
CA_4 x AF-D	-0.411 (0.272)
CA_5 x AF-D	0.530 (0.393)
CA_2 x AF-F	0.264** (0.0896)
CA_3 x AF-F	0.224* (0.110)
CA_4 x AF-F	0.176 (0.223)
CA_5 x AF-F	0.355 (0.424)
Additional Controls	Yes
Year Fixed Effects	Yes
Observations	1,725
R-squared	0.215

Notes: the dependent variable is Y. Robust standard errors in parenthesis. *, **, *** significant at the 0.05, 0.01 and 0.001 levels, respectively. Additional controls include EXP, EXP^2, AQ, EMP, NO-PhD and PhD-F.

Bibliography

Acedo, F.J., Barroso, C., Casanueva, C. and Galán, J.L. (2006), "Co-Authorship in Management and Organizational Studies: An Empirical and Network Analysis", *Journal of Management Studies*, 43 (5), pp. 957-983.

Azoulay, P., Zivin, J. and Wang, J. (2010), "Superstar Extinction", *The Quarterly Journal of Economics*, 125 (2), pp. 549-589.

Barnett, A., Ault, R. and Kaserman, D. (1988), "The Rising Incidence of Co-Authorship in Economics: Further Evidence", *The Review of Economics and Statistics*, 70 (3), pp. 539-543.

Bosquet, C. and Combes, P.P. (2013), "Are Academics Who Publish More Also More Cited? Individual Determinants of Publication and Citation Records", *Scientometrics*, 97 (3), pp. 831-857.

Bozeman, B. and Corley, E. (2004), "Scientists' Collaboration Strategies: Implications for Scientific and Technical Human Capital", *Research Policy*, 33, pp. 599-616.

Cardoso, A., Guimarães, P. and Zimmermann, K. (2010), "Trends in Economic Research: An International Perspective", *Kyklos*, 63 (4), pp. 479-494.

Chung, K., Cox, R. and Kim, K. (2009), "On the Relation Between Intellectual Collaboration and Intellectual Output: Evidence from Finance Academe", *The Quarterly Review of Economics and Finance*, 49, pp. 893-916.

Combes, P.P., Linnemer, L. and Visser, M. (2008), "Publish or Peer-Rich? The Role of Skills and Networks in Hiring Economics Professors", *Labour Economics*, 15, pp. 423-441.

Ductor, L. (2014), "Does Co-authorship Lead to Higher Academic Productivity?", *Oxford Bulletin of Economics and Statistics*, doi: 10.1111/obes.12070

Elsevier (2013), "Comparative Benchmarking of European and US Research Collaboration and Research Mobility: a Report Prepared in Collaboration Between Science Europe and Elsevier's SciVal Analytics", *SciVal Analytics*.

Fafchamps, M., Goyal, S. and van der Leij, M. (2010), "Matching and Network Effects", *Journal of the European Economic Association*, 8 (1), pp. 203-231.

Frenken, K., Ponds, R. and van Oort, F. (2010), "The Citation Impact of Research Collaboration in Science-Based Industries: A Spatial-Institutional Analysis", *Papers in Regional Science*, 89 (2), pp. 351-371.

Gordon, M. (1980), "A Critical Reassessment of Inferred Relations Between Multiple Authorship, Scientific Collaboration, the Production of Papers and their Acceptance for Publication", *Scientometrics*, 2 (3), pp. 193-210.

Guimarães, P. (2002), "The State of Portuguese Research in Economics: An Analysis Based on Publications in International Journals", *Portuguese Economic Journal*, 1 (1), pp. 3-25.

Hamermesh, D., Johnson, G. and Weisbrod, B. (1982), "Scholarship, Citations and Salaries: Economic Rewards in Economics", *Southern Economic Journal*, 49 (2), pp. 472-481.

Hamermesh, D. and Oster, S. (2002), "Tools or Toys? The Impact of High Technology on Scholarly Productivity", *Economic Inquiry*, 40 (4), pp. 539-555.

Hamermesh, D. (2013), "Six Decades of Top Economics Publishing: Who and How?", *Journal of Economic Literature*, 51 (1), pp. 162-172.

Hansen, W., Weisbrod, B. and Strauss, R. (1978), "Modeling the Earnings and Research Productivity of Academic Economists", *Journal of Political Economy*, 86 (4), pp. 729-741.

Hollis, A. (2001), "Co-Authorship and the Output of Academic Economists", *Labour Economics*, 8, pp. 503-530.

Hudson, J. (1996), "Trends in Multi-Authored Papers in Economics", *Journal of Economic Perspectives*, 10 (3), pp. 153-158.

Jonkers, K. and Tijssen, R. (2008), "Chinese Researchers Returning Home: Impacts of International Mobility on Research Collaboration and Scientific Productivity", *Scientometrics*, 77 (2), pp. 309-333.

Jonkers, K. and Cruz-Castro, L. (2013), "Research Upon Return: The Effect of International Mobility on Scientific Ties, Production and Impact", *Research Policy*, 42 (8), pp. 1366-1377.

Katz, J. and Hicks, D. (1997), "How Much is a Collaboration Worth? A Calibrated Bibliometric Model", *Scientometrics*, 40 (3), pp. 541-554.

Katz, J. and Martin, B. (1997), "What is Research Collaboration?", *Research Policy*, 26, pp. 1-18.

Kim, E., Morse, A. and Zingales, L. (2009), "Are Elite Universities Losing their Competitive Edge?", *Journal of Financial Economics*, 93 (3), pp. 353-381.

Laband, D. and Piette, M. (1994), "The Relative Impacts of Economics Journals: 1970-1990", *Journal of Economic Literature*, 32, pp. 640-666.

Laband, D. and Tollison, R. (2000), "Intellectual Collaboration", *Journal of Political Economy*, 108 (3), pp. 632-662.

Lee, S. and Bozeman, B. (2005), "The Impact of Research Collaboration on Scientific Productivity", *Social Studies of Science*, 35 (5), pp. 673-702.

Levin, S. and Stephan, P. (1991), "Research Productivity Over the Life Cycle: Evidence for Academic Scientists", *The American Economic Review*, 81 (1), pp. 114-132.

Liebowitz, S. and Palmer, J. (1988), "Assessing Assessments of the Relative Quality of Economics Departments", *Quarterly Review of Economics and Business*, 28, pp. 88-113.

McDowell, J. and Melvin, M. (1983), "The Determinants of Co-authorship: An Analysis of the Economics Literature", *The Review of Economics and Statistics*, 65 (1), pp. 155-160.

Medoff, M. (2003), "Collaboration and the Quality of Economics Research", *Labour Economics*, 10, pp. 597-608.

Melin, G. (2000), "Pragmatism and Self-Organization: Research Collaboration on the Individual Level", *Research Policy*, 29 (1), pp. 31-40.

Narin, F., Stevens, K. and Whitlow, E. (1991), "Scientific Co-Operation in Europe and the Citation of Multinationally Authored Papers", *Scientometrics*, 21 (3), pp. 313-323.

Piette, M. and Ross, K. (1992), "A Study of the Publication of Scholarly Output in Economics Journals", *Eastern Economic Journal*, 18 (4), pp. 429-436.

Presser, S. (1980), "Collaboration and the Quality of Research", *Social Studies of Science*, Vol. 10 (1), pp. 95-101.

Sauer, R. (1988), "Estimates of the Returns to Quality and Coauthorship in Economic Academia", *Journal of Political Economy*, 96 (4), pp. 855-866.

Wuchty, S., Jones, B. and Uzzi, B. (2007), "The Increasing Dominance of Teams in Production of Knowledge", *Science*, 316 (5827), pp. 1036-1039.

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