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Examining Italian scientists' propensity towards teamwork

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Abstract

Traditionally, one would start their study of research cooperation by field by categorizing publications based on the context of interest. In this paper, we suggest an alternate method based on the authors' disciplinary categorization. If the goal is to assess a person's tendency to work together, the suggested technique is more precise. This study applies the new technique to all hard science researchers at Italian universities, assessing their inclination to work with others in a variety of contexts. We use a simulation to illustrate how the findings vary significantly from those produced by using canonical methods.

1. Introduction

There has been an incredible increase in cooperation for the advancement of science during the last several decades. This is borne up by studies of co-authorship (Melin and Person, 1996), which show that the proportion of publications with a single author is steadily decreasing (Bat, 2007; Udine et al., 2012). Contextual variables, beginning with the research discipline, might influence the level of involvement in the various modalities of cooperation (intramural/extramural, domestic/international, interdisciplinary/interdisciplinary) (Gazing et al., 2012; Yoshikane and Kageura, 2004). Because of variables including expensive equipment costs, the need for massive sample sizes, and the method of assigning authorship, publications in the so-called "big scientific" fields tend to have much more authors than those in other fields (Cronin, 2001; Glanzel and Schubert, 2004).

Even among researchers working in the same field, there may be a wide range of approaches to fostering cooperation owing to varying levels of expertise and inclination to work together (Pipette & Ross, 1992). (Newman, 2001; Moody, 2004). In order to investigate the mechanisms at the very base of collaboration and define the most suitable policies for its management—policies that may lead to increased research productivity—it is necessary to be aware of the various forms in which collaborations across fields and disciplines are activated (Wagner and Leydesdorff, 2005). This article will explore how researchers from many fields of study approach and engage in collaborative research. It is common practice for such research to begin with a categorization of relevant papers. Instead, we base our method on the traditional divisions between scientific disciplines.

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The Italian educational system has a peculiar quirk that allows for this kind of approach. A seemingly unprecedented scenario exists in which the Italian Ministry of Universities and Research (MIUR) maintains a database2 of all national academics, with each person being assigned to exactly one Scientific Disciplinary Sector (SDS). There are 370 of these areas of study3, and they are organized into 14 broad academic disciplines (UDAs). If we can link writers to their works, we may examine how often researchers in various domains and disciplines work together and what kinds of projects they work on together. We may compare the findings from the two approaches by using a conventional technique based on publication categorization on the same population.

Abram et al. (2012) used the same methodological methodology to investigate the benefits of public sector research institutions that foster cooperation across disciplines. Conventional methodologies focused on categorizing the articles would not have allowed for this sort of investigation when considering occurrence. In this work, we aim to use co-authorship analysis once more to investigate other facets of research collaborations, in particular to identify any potential differences between scientists from different fields in their propensities to collaborate generally, and in intramural, extramural domestic, and extramural international collaborations.

Next, we provide a literature review before moving on to discuss our approach and the scope of our observations in Section 3. Section 4 shows examples of the outcomes obtained using the "author-classification" process, while Section 5 quantifies the differences between the two approaches. Finally, we suggest some future lines of inquiry and provide some suggestions for policy. Due to the highly skewed productivity distribution, with a few numbers of scientists producing the vast majority of the observations, it is more accurate to see patterns of cooperation based on authors' categorization than on classification data from publications. The decision to zero down on certain scientists also makes it possible to deduce how different types of cooperation are related to one another.

2. Scientific collaboration and its determinants

In the early stages of a scientific collaboration, when it is required to enhance familiarity and establish a climate of trust among collaborators, the ability to communicate in an effective, informal, and flexible way is one of the key components for growth of a fruitful collaboration (Triode and Landry, 1997). It's no wonder that many partnerships have their start in informal, in-person settings like water cooler chats, panel discussions, and kickoff gatherings, where participants' conversations are less filtered and more open (Laurel, 2001; Wagner and Leydesdorff, 2005). In long-distance cooperation, when monitoring is more difficult, face-to-face meetings may also assist to relieve challenges in coordination throughout implementation stages, preventing "free riding" and dispute among partners (Hinds and Bailey, 2003). Scientists are less likely to work together when there is a large gap in location between their respective institutions (Hoekman et al., 2010; Abramo et al., 2009; Larivière et al., 2006), which may be due to the significance of in-person meetings. This would also explain why scientists from different sized universities use different forms of co-authorship (Katz, 2000): those from large universities tend to collaborate primarily with colleagues from the same university or from foreign organizations, while those from smaller universities, due to the smaller number of their own intramural colleagues and the lower "relational" capital, tend to work with colleagues belonging to other domestic universities.

An obvious cause of the rise of scientific cooperation in recent years, particularly on a global scale, is the overall decrease in travel expenses (Hotelman et al., 2010). A key reason for this increase in extramural scientific partnerships, however, is the widespread availability of low-cost new communications technologies that have helped bridge the gap between remote and in-person interactions (Cairn cross, 1997; Olsen and Olsen, 2000).

3. Methodology, dataset and indicators

Methodology

Examining research partnerships typically involves identifying the type of partnership being studied (intra- or extramural, intra- or inter-disciplinary, public-private, domestic or international, etc.), situating the study within a specific field or set of institutions (such as a university), and using the co-authorships of the resulting publications as a measuring stick. Then, all of the articles that may be linked to the given context are sorted according to the studied methods of cooperation. To provide one concrete example, Gazing et al. (2012) define "international" publications in a field by the presence or absence of authors affiliated with foreign organizations. By dividing the number of "international" articles by the total number of publications in the field, researchers may get a sense of how common international cooperation is in the field as a whole. All the major indicators of co-authorship from Subramanian's (1983) "Degree of Collaboration" to Lawman's (1986) "Collaborative Index" to Ajiferuke et al(1988) .'S "Collaborative Coefficient" to Egg he's (1991) "Revised Collaborative Coefficient" are based on this method. Using a common measurement for all of your publishing data is another method for studying who wrote what. Individual scientists may be used as a basic analytical unit to assess how likely scientists are to interact in the form under consideration. To circle back on the phenomena studied by Gazing et al. (2012), assessing the inclination to international cooperation among scientists working in a certain field would be possible if individual scientists were used as the base analytical unit. Only Martin-Simpered et al. (2002) and Abram et al. (2009) come to mind as having taken a similar tack (2011). The latter quantified Italian scholars' tendency for interdisciplinary cooperation by determining the ratio of each scholar's publications with 7 or more foreign authors to their total number of publications. Overseas organization colleagues to the overall number of his or her articles. Although limited to 93 Spanish university-based geologists, Martin-Simpered et al. still determined each scientist's "degree of collaboration" and "degree of national collaboration," defined as the proportion of their total number of publications that were joint efforts with other scientists affiliated with the same country.

Data sources and field of observation

Our investigation relied on data from the aforementioned Ministry of Universities and Research database, which included profiles of Italian academics. After that, the writers use the Wes's permission and use it to access the Italian Observatory of Public Research (ORP), where they store a dataset of these authors' articles. Using raw data from 2006-2010 Italian Woos publications and a complex algorithm for disambiguating the true identity of the authors and their institutional affiliations (for details see D'Angelo et al., 2011), we are able to attribute each publication4 to the university scientist or scientists (full, associate, and assistant professors) that produced it with a harmonic average of precision and recall (F-measure) equal to 96 (error of 4%).

As a result, the bibliometric dataset furnishes the following information for each publication:

• A full list of contributors; both the full list of addresses and a separate list of academic writers with their SDS/UDA and institutional affiliations are provided. Table 1 summarizes data on the number of publications by and total number of Italian academics from the 11 UDAs included in this study. To make the bibliometric study even more rigorous, we've narrowed our focus to the 200 SDSs in which at least half of the faculty members published anything between 2006 and 2010. The number of faculty members in each UDA, the number of "productive" faculty members (those who produced at least one article indexed under the Woos in the period 2006-2010), and the number of "collaborative" faculty members all vary widely (at least one publication in co-authorship with other scientists in the same period).

Table 1: Main characteristics of the population of academics analyzed

UDA	Publications	Research staff		
		Total	Productive	Collaborative
Medicine (MED)	63,018	12,433	10,184 (81.9%)	10,174 (81.8%)
Industrial and information engineering (IIE)	37,283	5,644	4,846 (85.9%)	4,822 (85.4%)
Biology (BIO)	31,277	5,855	5,244 (89.6%)	5,237 (89.4%)
Chemistry (CHE)	25,687	3,610	3,384 (93.7%)	3,379 (93.6%)
Physics (PHY)	23,702	2,873	2,602 (90.6%)	2,575 (89.6%)
Mathematics and computer sciences (MAT)	16,131	3,607	2,905 (80.5%)	2,809 (77.9%)
Agricultural and veterinary sciences (AVS)	11,767	3,183	2,720 (85.5%)	2,714 (85.3%)
Civil engineering (CEN)	5,371	1,747	1,230 (70.4%)	1,209 (69.2%)
Earth Sciences (EAR)	5,284	1,423	1,181 (83.0%)	1,173 (82.4%)
Economics and statistics (ECS)	3,579	1,949	1,200 (61.6%)	1,100 (56.4%)
Pedagogy and psychology (PPS)	3,345	1,055	715 (67.8%)	705 (66.8%)
Total	197,460*	43,379	36,211 (83.5%)	35,897 (82.8%)

More over 80% of all academics are productive, however the percentage drops to just over 60% for economists and statisticians in the UDA and rises to over 90% for chemists. This disparity can be attributed, in part, to the fact that researchers affiliated with certain UDAs are more likely to publish their findings in venues outside of those counted by the Woos, such as specialized journals, conference proceedings, and books that may not be widely known outside of the country (Larivière et al., 2006).

4. Results and discussion

The numerous types of co-authorship may be analyzed, and distinct UDAs and their particular SDSs can be characterized, using the calculated C, CI, CED, and CEF values based on the registered propensity values for respective member academics. Our findings from sections 4.1 and 4.2 detail these analyses. The association among the four metrics is discussed in section 4.3.

Propensity to collaborate in different forms, in the various disciplines

Varied UDAs' faculty members have different intramural, extramural, and international partnership preferences. To better understand these distinctions, we provide a table for each type of collaboration that displays, for each UDA: I the values of average propensity to collaborate among the academics belonging to the UDA; ii) the percentage of academics with no propensity; and iii) the percentage of academics with maximum (100%) propensity. We use the Mann-Whitney U test (Mann & Whitney, 1947) to compare independent samples of UDAs and the Kruskal-Wallis test (Kruskal & Wallis, 1952) to compare independent samples of UDAs with known differences. These non-parametric tests allow us to see whether there is a greater or lesser inclination for academics to work together in one UDA compared to another. By using the kruskal.test and wilcox.test functions, we perform this analysis, and the findings (included in the Supplemental Material - S1) reveal that almost all of the comparisons we made had a high level of significance. Conclusions allow for grouping UDAs according to their varying degrees of cooperation. Collaboration probabilities are shown in Table 2. The proportion of co-authored papers within the "bibliometric" fields is currently over 90%, which is consistent with several other studies using other techniques (Abt, 2007; Gazing et al., 2012). Although the findings from the Mann-Whitney U test are generally very significant, Table 2 reveals little variations across various UDAs in the inclination to cooperate. Particularly, the average inclination to cooperate approaches 100% in the fields of medicine, agriculture and veterinary science, biology, and chemistry.

These findings largely corroborate those of Haiti and Hong (1997) and Gazing et al. (2012), although the latter authors demonstrate a trend toward increased similarity amongst the various fields. Similar patterns are shown in the work of Gazing and Diego (2011), with the exception of the UDA values for the fields that make up agricultural and veterinary sciences, which are found to be lower than those for the fields of mathematics and computer science in their study. Actually, our findings reveal that this later UDA, along with Economics and statistics, has the weakest tendency to work together. We also find that, relative to other UDAs, Physics has a rather high value of the inclination to cooperate, perhaps due to the influence of certain subfields within the larger field. In Section 4.2, we will go further into this topic and explore the varying tendencies to cooperate among the SDSs that make up this field of study.

Table 2: Propensity to collaborate, per UDA (percentage values)

UDA	*Mean C*	*% C = 0%*	*% C = 100%*
Medicine (MED)	99.4	0.1	94.8
Chemistry (CHE)	99.2	0.1	94.8
Agricultural and veterinary sciences (AVS)	99.1	0.2	95.7
Biology (BIO)	99.1	0.1	94.4
Earth sciences (EAR)	97.6	0.7	90.6
Industrial and information engineering (IIE)	97.1	0.5	85.5
Pedagogy and psychology (PPS)	96.7	1.4	89.8
Physics (PHY)	96.6	1.0	81.5
Civil engineering (CEN)	94.3	1.7	81.5
Mathematics and computer sciences (MAT)	89.1	3.3	68.6
Economics and statistics (ECS)	84.0	8.3	70.1
Total	97.2	0.9	89.0

When comparing intramural cooperation, the disparities between the different UDAs seem to be considerably more evident. According to the data shown in Table 3, there is a significant gap between the UDA with the highest value (Chemistry) and the one with the lowest value (Physics) (Economics and statistics). These findings, along with those from the Mann-Whitney U test, demonstrate that the propensity to collaborate with colleagues from the same institution is once again quite high in the four UDAs of Medicine, Agricultural and Veterinary Sciences, Biology, and Chemistry, which previously registered the highest general propensity to collaborate. This finding makes sense when you think about the fact that professors in these fields often work in laboratories owned by their own institution, which they frequently share with other colleagues for economical reasons. Industrial and information engineering has the second greatest tendency for this kind of cooperation. This finding makes sense when you consider that, like many other academic fields, this one relies heavily on shared institutional resources like laboratories, equipment, and software amongst researchers across departments and schools within the same university, making the formation of productive collaborations much simpler. In addition, many engineering studies are the end result of research projects commissioned by companies and carried out by academics, which then prefer to collaborate with their peers at the same institution rather than those at other institutions in order to save money on travel, office space, and other overhead while still maximizing their impact. It is not straightforward to compare the computed values of propensity to intramural cooperation in this study to those reported in other bibliometric studies, since the latter do not include mapping of research conducted only via intramural collaboration. Since the current methodology can identify and map intramural partnerships even when the relevant publications reveal different institutional addresses, it allows for a more thorough examination of the importance of intramural collaborations7.

Table 3: Propensity to intramural collaboration, per UDA (percentage values)

UDA	Mean CI	% CI = 0%	% CI = 100%
Chemistry (CHE)	83.5	2.4	46.1
Industrial and information engineering (IIE)	82.2	3.9	46.9
Agricultural and veterinary sciences (AVS)	81.2	4.3	51.8
Medicine (MED)	81.1	3.6	45.9
Biology (BIO)	78.8	4.2	45.8
Civil engineering (CEN)	73.4	8.8	46.3
Physics (PHY)	66.7	8.7	29.2
Earth sciences (EAR)	62.0	11.4	31.1
Pedagogy and psychology (PPS)	59.6	18.2	35.8
Mathematics and computer sciences (MAT)	54.1	20.5	25.4
Economics and statistics (ECS)	44.0	36.0	26.7
Total	75.4	7.2	42.3

One way to categorize extramural partnerships is by whether or not the extramural organization is domestic or international. Average propensities to work with scientists from different domestic organizations outside of the institution are shown in Table 4. Again, disparities across fields are quite obvious, with over half a century separating the UDAs with the highest and lowest average tendency (Physics and Philosophy, respectively) (Industrial and information engineering).

Table 4: Propensity to extramural collaboration at the national level, per UDA (percentage values)

UDA	Mean CED	% CED = 0%	% CED = 100%
Physics (PHY)	72.5	5.6	24.9
Medicine (MED)	62.4	8.2	20.6
Earth Sciences (EAR)	58.6	13.1	23.3
Biology (BIO)	57.4	9.8	17.5
Chemistry (CHE)	49.8	8.3	9.3
Pedagogy and Psychology (PPS)	48.5	26.3	22.2
Agricultural and veterinary sciences (AVS)	47.1	17.3	13.9
Economics and Statistics (ECS)	38.0	38.9	19.1
Mathematics and Computer Sciences (MAT)	33.6	33.3	10.7
Civil engineering (CEN)	26.0	44.3	8.2
Industrial and information engineering (IIE)	24.8	33.1	5.3
Total	50.3	17.0	15.7

These findings are consistent with a prior study conducted by Abram et al. (2009a), which looked at the number of scholarly works produced as a consequence of partnerships between Italian institutions in the years 2001-2003. When taken in conjunction with the result obtained for the tendency to intramural cooperation, the low value seen in the engineering disciplines illustrates how partnerships are highly significant for these fields but is mostly implemented inside the confines of the specific institution. This might be because most research is conducted at individual universities and the resources needed for it are readily accessible there. However, in Physics and the other "big science" fields, the engagement of scientists who belong to organizations outside of a particular institution is vital due to the extensive resources (e.g., equipment, numbers of observations, multidisciplinary abilities) required for research. Supporting this interpretation is a synthesis of research on the likelihood that researchers would work with scientists from foreign institutions (Table 5).

Table 5: Propensity to extramural collaboration at the international level, per UDA (percentage values)

UDA	Mean CEF	% CEF = 0%	% CEF = 100%
Physics (PHY)	51.7	12.2	10.0
Earth Sciences (EAR)	32.8	34.3	7.9
Pedagogy and Psychology (PPS)	31.8	40.1	11.7
Economics and Statistics (ECS)	27.5	52.3	12.1
Biology (BIO)	27.1	28.9	3.6
Mathematics and Computer Sciences (MAT)	26.9	39.6	6.5
Chemistry (CHE)	25.2	26.4	1.3
Agricultural and veterinary sciences (AVS)	20.1	43.8	3.2
Medicine (MED)	18.6	41.7	2.9
Civil engineering (CEN)	15.3	59.3	2.8
Industrial and information engineering (IIE)	13.4	50.0	1.5
Total	23.8	38.1	4.1

Given the previously mentioned frequency of intramural partnerships, the low value of propensity recorded in the engineering disciplines, where over half of academics did not work at the international level in this time, makes sense. Tijssen & Van Wijk (1998) found that Italy had a greater domestic publishing percentage in the ICT engineering specialities than for other European countries; hence this condition may possibly indicate a fact specific to the disciplines in the Italian setting. The Mann-Whitney U test confirms that the highest rates of international cooperation are seen in the fields of physics and earth sciences. Numerous studies in the literature (Luukkonen et al., 1992; Glanzel and Schubert, 2005; Olmeda-Gómez et al., 2006; Abram et al., 2011) corroborate this finding, which is largely attributable to the fact that much research in these fields necessitates observations so complex and equipment so costly that can only be obtained through international collaborations. The categorization of fundamental and applied disciplines proposed by Frame and Carpenter may also explain why certain UDAs are more likely to engage in international cooperation than others (1979).

6. Conclusions

Several researchers have taken an interest in the study of research cooperation's many forms in order to theorize about the variables that could influence the patterns of collaboration seen in different academic disciplines. So far, this has been done via the use of indicators of incidence based on counting articles. Instead, the authors of this article suggest a novel methodological approach that takes the individual scientist as its unit of analysis. This method has several benefits, including, most importantly, the ability to conduct large-scale analyses of inter-disciplinary partnerships. Indeed, basing the quantification of the collaboration phenomenon on counting of publications implies obvious distortions in the case where productivity, apart from collaboration intensity, is not distributed in a homogeneous fashion (the real-world situation) mad, more generally, the proposed approach certainly permits a more truthful picture of the propensity of researchers to collaborate in the various forms, whether with their direct colleagues or with other organizations.

For accurate ex-ante formulation and ex-post management of policies to generate, adjust, or maintain the circumstances for various types of collaboration within any reference framework, the installation of dependable collaboration measurement systems is in reality vital. Given the potential benefits in terms of increased abilities to generate and disseminate new information, it is not surprising that many countries have laws designed to encourage scientific cooperation. In order to confirm that such a strategy has had the desired impact on the actors who are its intended target, the individual scientist's tendency to cooperate may be measured. In addition, starting with data on individual scientists, one may acquire the assessment of the tendency to cooperate for the person's research group and organizational unit at rising levels, which can then be the subject of special policy.

In conclusion, our method provides a more acceptable means of implementing policies meant to influence scientific partnerships than the methods offered in the literature up until now. Our method has been applied to the research activity of Italian academics, allowing us to quantify their tendency to interact using various forms, across disciplines. The findings can be utilized in two ways: first, to assess the efficacy of previous policies implemented by individual universities or the research system as a whole; and second, to inform the development of new policies designed to promote collaborations that account for the unique characteristics of different academic fields.

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