

FEMININE PARTICIPATION IN COLLABORATIVE NETWORKS OF SCIENTIFIC PUBLICATIONS IN THE FIELD OF ECONOMICS: Social Network Approach for Portuguese Researchers

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Abstract: This paper's aim is to ascertain the existence of scientific collaboration in publications done by Portuguese researchers in the years 2014, 2015 and 2016 (just until June of this last one). For such, all areas quoted by the authors are identified as knowledge areas pertinent to the domains they fit in addition to Economy, which is the main field. The data analysis is made through the approach of social networks that, in this case, is constituted by all the articles that point out a second area of knowledge in common and highlighted by gender. The main results indicate that Business is the area that gathers the greatest connection between the coauthors and that women increase their publications since they research along with men.

Key Words: scientific collaboration, gender, social network.

PARTICIPAÇÃO FEMININA EM REDES COLABORATIVAS PARA A PUBLICAÇÃO CIENTÍFICA EM ECONOMIA: Abordagem de Rede Social Para os Pesquisadores Portugueses

Resumo: O foco deste trabalho é averiguar a existência de colaboração científica nas publicações realizadas pelos pesquisadores portugueses nos anos de 2014, 2015 e parcela de 2016. Para tal, são identificadas todas as áreas citadas pelos autores como áreas de conhecimento que seus trabalhos se enquadram após a área principal que é Economia. A análise dos dados é feita por meio da abordagem de redes sociais que, neste caso, é constituída por todos os artigos que apontam uma segunda área de conhecimento em comum e destacada por gênero. Os principais resultados indicam que Business é a área que congrega a maior ligação entre os coautores e que as mulheres aumentam suas publicações a partir do momento que realizam pesquisas conjuntas com homens.

Palavras-chave: colaboração científica, gênero, rede social.

1 INTRODUCTION

Publications through partnerships are becoming increasingly common among researchers. Scientific research has started to be shared between pairs as a mean of improving results, sharing knowledge, as an engine of physical and monetary resource sharing, to increase the productivity of researchersⁱ or for interdisciplinary research development (Katz and Martin, 1997; Bozeman and Corley 2004; Abramo and al., 2013; Guan et al., 2016; Tijssen and al., 2012; Wagner and Leydesdorff, 2010).

Collaborative research has broken the barriers of laboratories or educational institutions and has become universal. The partnerships are established beyond institutions and shared with other countries and with other regions or institutions within the country itself. Technologies of information and communication have facilitated this new conception for researches and publications. (Hoekman et al. 2010; Abramo et al., 2013).

The last decades have shown the advancement of interdisciplinary collaborative researches. Most researchers believe the interconnection between different areas of scientific knowledge to influence positively on the results of researches, obtaining superior levels of success in terms of theoretical, practical and innovative results (Karlokveec and Mladenec, 2014).

Researchers believe the interdisciplinary research to be a modern society demand, requiring answers from different areas of knowledge (Van den Besselaar and Heimeriks, 2001; Uzzi et al.2013). Researches done since the 80's show several ramifications in the area of the Economic Science -multidisciplinary and interdisciplinary-, and its ample significance to complement and execute researches in various fields of knowledge, such as Mathematics, Statistics, Management, Sociology, Politics and History (Krinkel and Bakkalbasi, 2006; Pieters and Baumgartner, 2002). According to Araújo and Fontáinha (2016), in the 70's decade researchers in the area of Economics had, in average, less than one coauthor per publication. This number has doubled in the 90's and has grown considerably since 2000.

Another phenomenon spotted in publications about collaborative networks of research was the increase of feminine participation in the most varied areas of

knowledge. The Gender report in the Global Research Landscape published by Elsevier (2017), reveals the rise in the proportion of women among researchers and inventors over time in the 12 (twelve) studied countries. The researchers universe of nine of those countries is made up of more than 40% of women, being Portugal and Brazil the most salient ones. In these two countries, the number of females tanking place in researches represented 49% of the researchers population between 2011 and 2015. However, during the period of 1996-2000 only Portugal had more than 40% of its researchers population formed by women.

Various researches in several countries have and are being published with the objective of analyzing the disparity, motivation, characteristics, patterns and impacts of scientific publications made by men and women. In terms of scientific productions coming from collaborative networks the results vary, depending on country, region, area of knowledge, among other factors (Hogan et al., 2010; Bozeman and Gaughan, 2011; Abramo et al., 2013; Blume-Kohout, 2014; Abramo et al., 2015; Meng, 2016; Araújo and Fontáinha, 2016; Elsevier, 2016).

The analysis of this context led to the surge of curiosity on researching about the constitution of the network of scientific collaboration of the Portuguese researchers in the area of Economic Science. This work aimed, mainly, to characterize the network of scientific collaboration in Economy and its subareas to, therefore, determine the existing connection between researchers according to their gender.

Initially, to achieve the objective, all articles published in the area of Economy by researchers bound to Portuguese institutions of teaching or research in 2014, 2015, 2016 (just until June of this last one) were selected. Then, other 29 (twenty nine) subareas quoted by the authors as field of knowledge in which their researches fit were classified to identify existing connection between researchers according to their genderⁱⁱ. The attributes used to identify the structures of collaborations were the scientific subareas quoted by the coauthors beside Economy, which was the main.

To explore the thematic, this work is divided into six sections, including this introduction. In section 2, the arguments relative to scientific collaboration and its determinants are presented. Section 3 describes the difference of gender in collaborative

publications. Section 4 shows the research methodology and general data statistics. In section 5 the analysis of results of social networks built from the collaboration in publications is pointed up, having the scientific area of connection between works as an attribute. Lastly, in section 6, conclusions and suggestions for research continuation are presented.

2 BIBLIOGRAPHIC REVISION

Scientific collaboration is defined by Katz and Martin (1997) as joint work of researchers to achieve the common goal of producing new scientific knowledge. According to the authors, the usage of co-authorship data or of the author's institutional connections in scientific publications has been the most common way of measuring scientific collaboration.

Several bibliometric studies point that collaborative research has presented substantial growth in the last two decades. This conclusion is associated to the verification of the expansion of national and international research networks (Abramo et al., 2013; Guan et al., 2016; Tijssen et al., 2012; Wagner and Leydesdorff, 2010). The reasons that lead researchers to amplify the number of participants in their research projects are varied. This will depend on the research goal, the research area, and the type of network of scientific collaboration of the projects author, among others.

The request for partnerships in research is related to the demand for high performance researchers in specific areas of knowledge: for economic reasons, for research funding and sponsoring purposes, editors requiring internal and external partnerships, and even for the search for higher quality partnerships that can bring more quality and intensity to the publications made (Katz and Martin, 1997; Abramo et al., 2013; Tijssen et al., 2012; Hoekman et al., 2013; Tijssen et al., 2012; Hoekman et al., 2010).

Gazni et al. (2012) affirm that collaborative research has benefits and merits, once in its scope researchers are sharing and transferring knowledge and connecting scholars to a large scientific network. Bozeman and Corley (2004), who described collaborative research as a result of a series of factors, standing out the equipment and

resources sharing for researches and the search for professionals with expertise in a determined area of knowledge, also defended this point of view. About this last one, it is not only scientific knowledge, but also the ability to plan and structure researches, as well as building new contact networks.

Hoekman et al. (2010) highlight that the growth of cooperation in scientific collaboration occurred through inter-institutional, inter-organizational and international ways. Technology of information and communication facilitated the enlargement of researches between countries, many times widely encouraged as a political strategy for the development of science and technology of many nations.

In this sense, the study of Tijssen et al. (2012) shows that between 2000 and 2010 some countries increased significantly the number of publications stemmed from researches done in collaboration with other countries. Standing out: France, Canada, the United States, Brazil and China. These countries are distinguished as well for the growth of collaboration in scientific research within their borders. Hoekman et al. (2010) made a similar study for the period of 2000-2007, concluding that there was a rise in geographic distance between research partners and a clear tendency for growth in co-publication between different countries.

The subjects that present the highest collaboration and consequent elevation of the number of publications co-authored are physical sciences (spatial, computational, geoscience, mathematics); life sciences (biology, physics, chemistry, agriculture, pharmacy, biochemistry, neuroscience, immunology, microbiology, plants and animals, environment); engineering; social sciences and humanities (Hoekman et al., 2010). A similar study done by Gazni et al. (2012) point high co-authorship in publications of physics and life sciences, while social sciences and multidisciplinary publications still possess low levels of collaboration.

The publication of Gazni et al. (2012) indicates also that countries that cooperate intensively are the United States, the United Kingdom, Germany, France, Italy and Canada. These six countries represent 82% of all the collaborative publication in the world. The countries with the slightest rates of collaboration in international publications are Turkey, India and Taiwan.

Several publications about the collaboration in scientific research cared about showing the female participation in collaborative networks. Historically, women possess lower indexes of co-authorship in scientific national and international publications. The characteristics of female participation in scientific collaboration networks are emphasized in the following section.

2.1 Differences Between Genders In Collaborative Research

Recent studies point out that the female participation in researches where collaboration networks exist is still slightly lower than the male one (Hogan et al., 2010; Bozeman and Gaughan, 2011; Abramo et al., 2015; Meng, 2016;). The authors recognize that many factors lead women to have a different profile in terms of collaboration in scientific research, and several reasons that lead them to have minor participation in national and international social networks of collaborative research in some areas.

Bozeman and Gaughan (2011) claim that the differences of gender in collaboration are associated to distinct factors that can imply in crucial matters relative to research and education. These matters include the formation of the team, instruction of professionals, researcher's representativeness, recruitment and retention of human capital (scientists and technicians) and even the quality of the research.

According to the authors, comparing groups of men and women that work in academic research and that are single, a lower productivity behavior is observed in terms of publications and in terms of collaboration for both groups. When the researchers are married, women have a bigger share of hours by day dedicated to the children and family, reducing scientific productivity.

The disparity between genders in collaborative research initiated in scientific initiation programs offered in graduations of educational institutions, where women are less searched for research projects with orientation. Normally, women participate in research projects in groups facing the field of humanities and in the last decades in social sciences (Bozeman and Corley, 2005; Abramo et al., 2015).

Meng (2016) describes that psychology studies show that both genders believe men to possess some important qualities to participate in research projects and collaboration networks that women do not, such as: they are more assertive, competitive, aggressive, courageous and instrumental. According to the author, cultural factors still prevent many female researchers from accessing financial resources, as well as human and material ones. This can explain partially why women that work as teachers and researchers in universities present smaller scientific productivity (publications, deposit of patents, great discoveries, etc.). Meng (2016) goes further showing researches concluding that scientific research was predominantly male until the beginning of the 90's. Women were generally treated as “outsiders”, strangers or not legitimate members of the research group.

Various social processes that tend to create barriers to prevent changes from occurring reinforce such beliefs. The production of scientific knowledge is a complex process that involves several stages such as discussing the research's theme, trading information to generate an idea or debate the results of data analysis. As men are generally the ones that command research groups, they tend to choose other men to interact and research with (Meng, 2016).

Abramo et al. (2015) emphasize that there has been a slight growth of female participation in scientific production, however women are still less representative than their male colleagues. As an example, they quote that female researchers in university institutions deposit 60% less patents than men researchers. They also describe that in many scientific areas female performance is not inferior to the male one. However, many times, even in these areas, men still appear in the privileged position of first and last name in the list of authors. They also affirm that just a few women are published alone.

These disparities can be explained by lower participation of women in scientific initiation or, in some cases, by the called “Matilda effect”, which occurs when women collaborate for the research market, but are not cited in the published articles (Abramo et al., 2013; Abramo et al., 2015). From the moment women initiate their professional career the challenges are various. As commented before, a factor that significantly

reduces scientific productivity is the family. The conduct of marriage and children tends to generate effects over the level of specialization of female professionals. Women that take more time for the family tend to be less specialized, implying lower scientific production, as well as minor participations in international collaborative research.

Abramo et al. (2013) and Bozeman and Corley (2004) report that women that act in the academic environment tend to develop less cosmopolitan formal collaborations and contact networks (with a minor number of participants and minor institutional reach), however, they tend to have bigger propensity to interdisciplinary collaboration. The collaboration has a big importance for impact publications and in scientific productivity by women. Other statement is that female researchers create collaboration networks since the beginning of their careers, while men do this after making solid their individual reputation. This choice by women can affect the impact their publications have, because they participate in researcher networks with lower individual visibility.

Publishing in a collaborative way since the beginning of the career is not always a simple choice, in most cases it is a necessity. Collaborative research and publication are the found means through which most women are inserted in the academic universe and, in a certain way, are established as researchers (Abramo et al, 2013; Abramo et al, 2015; Meng, 2016).

Blume-Kohout (2014) points out the smallest female participation in activities that involve basic science, technology, engineering and mathematics. The report involved elements such as research activities, industry development, and engagement of women in undertaking from their scientific discoveries. In all cases, women showed less participation.

All the recent empirical studies highlighted before emphasized that there has been an evolution of female participation in the academic area, in national and international collaborative research, in the number of deposited patents and in diverse activities connected to research and development.

However, the authors of the works outline concerns as to the way women are still seen in various research areas. They show the need of politics to stimulate women

to occupy the place of chief-researchers in the areas of basic science, engineering, and computation science amongst others. Such concerns are valid once that the growth of women participation in the academics and scientific world is still recent.

3 METODOLOGY

This research used data were extract from Intitute for Scientific Information Web of Science (WoS) database, following the criterias: a) Articles must had been published on indexed magazines; b) The main knowledge area must be Economics; and c) At least one of authors should had been associated on a Portuguese Education and Research Institution's. The research's universe was 440 publications for the years 2014, 2015 and 2016 (until june month).

After the selection of the publications, the classification of the authors/co-authors was made by the number of male and female participants. All articles were analyzed to check if the authority was only masculine, only feminine or blended. It was also observed if there was collaboration in the publications: only by men, only by women or both, as seen in Table 2. Next, it was sorted by area of knowledge. All the articles mentioned Economy in the first place, and then other scientific subareas, like Finance, Business, Health, Environment, amongst others. Twenty-nine cited subareas that complement the main area were found (Table 1).

Table 1: Secondary Areas

Id	Subject	Id	Subject
1	Agricultural Economics	16	Leisure, Sport & Tourism
2	Area Studies	17	Management
3	Business	18	Mathematics
4	Cultural Studies	19	Occupational Health
5	Ecology	20	Operations Research
6	Education	21	Planning & Development
7	Environmental Studies	22	Political Science
8	Finance	23	Science & Technology
9	Geography	24	Social Sciences
10	Health Policy	25	Sociology
11	History Of Social Sciences	26	Statistics & Probability
12	Hospitality	27	Transportation
13	Industrial Relations & Labor	28	Urban Studies

14	Interdisciplinary Applications	29	Engeeniring
15	International Relations		

For the purposes of this research up to five subareas of connection for each article were considered. The structure defined in Table 2 represents the stratification of each article, by gender and by subarea of knowledge. The column Id shows the identification of the articles, the column WOMAN an MAN represent the number of female and male authors, respectively. The columns 1, 2, 3, 4, and 5 mean presence and classification of the subareas of knowledge quoted in each published article.

For example, the article 001 analyzed had two female and zero male authors and was defined in the subareas Ecology (5) and Environmental Studies (7). Meanwhile, the article 003 presented collaborative network between one female and one male authors, but with no classification subarea.

Table 2: Classification of the articles by gender and subarea of knowledge (P_{440,5})

Id	Gender		Subjects				
	Woman	Man	1	2	3	4	5
001	2	0	5	7	0	0	0
002	0	3	10	18	0	0	0
003	1	2	0	0	0	0	0
...
440	3	1	9	3	0	0	0

Because the research needed subareas of knowledge to identify connections between authors, from the universe of 440 analyzed articles, just 208 were linked to each other by at least one of the five subareas classified. Therefore, the social network of authors and the analyzed subareas was composed by the following groups: $P_{(440,5)}$ = total universe; $P^0_{(208,5)}$ = articles with at least one subarea. Each cell in the grid is represented by an article (i) that possesses at least one subarea (j), where j ($p^0_{i,m}$) being $0 \leq j \leq 29$. The subarea is represented by (m), being ($1 \leq m \leq 5$).

In Table 3 it is observed that the number of articles published exclusively by women represented just 9.1% of the total (440 articles), while those published exclusively by men are 50.9% of the total. Women made 32.5% of publications

individually and men 21.9%. When male researchers publish along with other men, the cooperation is, in average, of 2.3 people. When the cooperation is blended, the average is three people per article.

Table 3: Sample Statistics

	Authors								
	Exc. Fem.		Exc. Male		Fem. E Male		Total	Inc. Fem.	Inc. Male
Number Articles	40	9,1%	224	50,9%	176	40,0%	440	216	400
Average co-authors	2		2,3		3		2,6	2,9	2,65
Individuals publ.	13	32,5%	49	21,9%			61		
2º Subject publ.	24	11,5%	99	47,6%	85	40,9%	208	109	224

It is possible to verify that- out of the 208 publications that pointed out that at least one of the 30 scientific classified subareas- 11.5% were written exclusively by female cooperation ($P^1_{(24.5)}$) and 47.6% by male cooperation ($P^2_{(99.5)}$). It is interesting to observe that the joint publications ($P^3_{(85.5)}$) consist of 40% of the total spectrum, both for the total number of articles and for the connections by second scientific subject.

4 ANALYSIS OF THE DATA OF THE SOCIAL NETWORK

The analysis of the results of the social network of the publications shows with more clarity the existing connections between the publications made in a collaborative way. These networks are presented in the classifications by gender and by scientific subject.

In Figure 1, the results (for division by gender) of the *bipartite* network of the 208 articles that present at least one subarea of connection beyond the main area are highlighted. The articles written in joined collaboration between men and women are identified in blue, those written in collaboration exclusively between men in orange and those written in exclusively feminine collaboration in green.

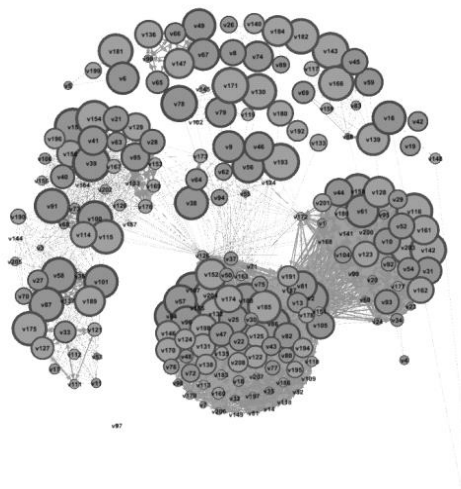


Figure 1: *Bipartite* network of shared articles, colored according to gender, 2014-2016.

This network confirms the general statistics previously presented, showing that male publications are broadly collaborative. It is also possible to highlight that the existence of co-authorship elevates significantly female publications, meeting the theory and other empirical studies on collaboration as an instrument used often to improve the researcher performance. Here, in virtue of the characteristics of the network attributes, it is not possible to analyze the reasons whereby the links occur, such as if women are in the beginning of their career, or if the collaborations are between departments of the university, among others.

For the classification of the co-authorship connections, it is observed that the most quoted area by the co-authors was Business. According to the Figure 2, in order of participation importance of the publications in collaboration, by subarea, there is Transports, Environment, Health Politics, Hospitality, Geography, Mathematics, Agriculture Economy, Management, and so on.

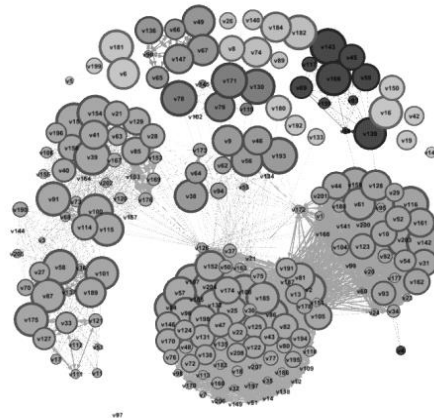


Figure 2: Subareas *Bipartite* network of published article with participation of both genders, colored according to subarea.

In this case, the subarea in which the most authors collaborate is Business. This subarea has a strong connection between itself and the other areas, according to the presented edges and nodes.

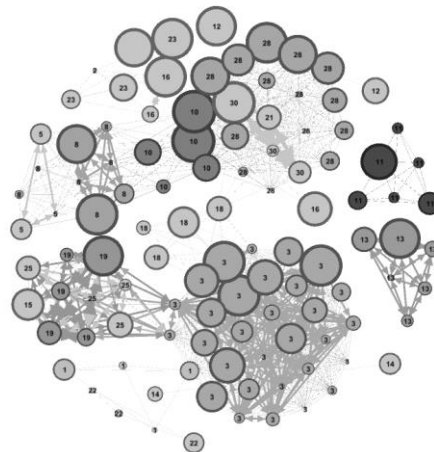


Figure 3: *Bipartite* network of articles with feminine co-author participation, colored according to subarea, 2014-16.

Considering only publications where women possess co-authority, whether with other women or with men, it is perceived that the most quoted subareas follow the tendency of the previous classification. As shown in Figure 3, the area of the most feminine co-authority is Business followed by Transportations.

In a general way, publications where there is female participation are similar to the total network previously presented. The highlight of this network is up to the intensity of connections of the subareas: Mathematics and Transportations with Business and other subareas. It is also interesting to observe that when there is female co-authority the subareas of Hospitality, Geography and Environment possess important links between each other and with all other areas.

According to empirical studies emphasized previously, women tend to collaborate more in the areas of Social Sciences and Humanities, such as Business, Management, Political Sciences, History, Education, etc... Fact that has not been totally confirmed by this network.

5 CONCLUSIONS

This study's goal was to ascertain the collaboration structure in publications made in the area of Economy. Articles that pointed at least one Portuguese co-author or where at least one of the co-authors was associated with a Portuguese research or education institution were selected. The analysis of the formed social network by these authors was divided in two parts.

In the first it was found that men present the most individual publications, however, they are very collaborative, with pairs of the same gender as well with feminine pairs. Women extend significantly the publications with co-authorship when collaborating with authors of the masculine gender. It is important to highlight that this is a characteristic pointed out in other empirical studies made in different countries with different attributes to classify the level of collaboration between men and women.

The second part of the analysis' attribute of connection between the articles was the scientific subareas quoted by the authors. Business was the one that stood out, as it presents the biggest connections between authors and both genders. The highlight was Transportation and Mathematics in the network where all feminine published articles

are configured, whether the collaboration was exclusively feminine or blended. This means that there is a preference for collaboration in Portuguese author publications.

The verified network coefficients point out that the most intense connection is in the Business area since it presents the biggest centrality of the ensemble of highlighted areas. Business configures as a link for other five subareas for when all articles that are made in co-authority are considered.

It is stressed that this study is only an initial approach about collaborative research of Portuguese researchers/authors. For better understanding, it is interesting to search new attributes such as the connection of co-authors by affiliation institution, or their own connection by geographic area.

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ⁱ Even though scientific productions are used as a measurement to evaluate researchers in their institutions, as well as by organs promoting worldwide research, this is not the main reason to research through collaborative networks.

ⁱⁱ This article did not intend to discuss gender matters, which are wide and complex. For the qualification of the authors by gender, it was considered male and female.