Social Capital and Selectivity in Academic Co-Authorship Networks: the Case of Accounting Sciences in Brazil

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ABSTRACT

Social capital has been mobilized as an explanatory variable in various empirical studies, but these studies have been unable to overcome the ambiguities inherent in a pre-scientific notion. The present study tests structural autonomy, one of the two established hypotheses on social capital, from the point of view of social network analysis. The test is applied in a case study of the academic co-authorship networks of accounting science programs in Brazil during the period from 2002-2010. The dynamics of selectivity present in this specific network, i.e., criteria of intertemporal choice, institutional endogamy and mutual choice by productivity, were also analyzed. We observed that there were negative correlations between the authors' constraints and their academic productivity indices, cascading intertemporal choices and endogamous choices according to institutional and productivity criteria.

Keywords: Social capital. Structural autonomy. Co-authorship networks. Selectivity.

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1 INTRODUCTION

The conceptual elaboration of social capital is undoubtedly the most important export from sociology from the past thirty years. James Samuel Coleman (1988, 1992, 1994) and Pierre Bourdieu (1980) contributed decisively to the scientific dissemination of this concept, although they were attempting to clarify different matters. Coleman (1988) was concerned with what he regarded as the fundamental problem of contemporary asymmetric societies – the lack of solidarity between individuals occupying pre-established positions in large organizations designed by human will. He appealed to what he regarded as the imperative of the rational reconstruction of society or to the discovery of looser forms of social organization in which rational individuals would find incentives to forge lasting social ties. Bourdieu (1980), for his part, undertook the critical task of preventing the expansion of the concept of capital to non-economic spheres of social life. He argued that sociology would be able to identify mechanisms in which inequality was socially reproduced that were invisible when economists focused on the academic world, armed with the concept of human capital. For Bourdieu (1980), there are other forms of capital – cultural, symbolic and social – that feed into each another and thus contribute to the reproduction of social domination.

The representation of social capital has remained, for many years, with an ambiguous notion that is commonly used, despite the theoretical and methodological efforts of Coleman (1988, 1992, 1994) and Bourdieu (1980). Empirical studies in various fields illustrate many situations in which social capital is mobilized as an explanatory variable, but these studies have been unable to overcome the ambiguities inherent in a pre-scientific notion. For example, Coleman (1988) studied the problem of school dropout and operationalized social capital in terms of family cohesion, identifying it empirically in the dense interactions between parents and children for the purpose of school learning. In this pioneering study, the central hypothesis was that a high level of social capital, both intra- and inter-family, would have a positive impact on children remaining in school. However, certain ambiguities remain in Coleman (1988)'s study and are embodied in the following questions: Can the collective and relational resource called social capital be appropriated by individuals? How can we discern what corresponds to the agent and what corresponds to the structure? In the twentieth chapter of *Foundations of Social Theory* (1994)*,* Coleman posits that social capital may be taken as a public good that may be built or destroyed by the *by-products* of an individual's actions but does not specify the social mechanisms that build or destroy social capital.

Instead, he simply hypothesizes that a dense structure of relationships among adults would be the source of a social capital that would have a positive impact on the academic performance of children (Coleman, 1988). This line of thinking requires a more rigorous analysis to differentiate the social problems to which the concept of social capital is applied from the theoretical and methodological perspectives with which social capital becomes operative.

2 ANALYTICAL FRAMEWORK FOR DIFFERENTIATING STUDIES ON SOCIAL CAPITAL

Much of the ambiguity and confusion in the implementation and operationalization of social capital results from a failure to distinguish between minimalist and maximalist social actions (OSTROM; AHN, 2003). While the former focuses on the strategic investment that is undertaken by individuals in the construction of social relationships, the latter focuses on the social mechanisms that enable dilemmas of collective action to be resolved (OLSON, 1989). The table below shows several pure types of social capital and summarizes the methodological strategies used to study them:

	Econometric studies *Probability sampling*	**Sociometric studies** *Social network analyses*
Minimalist social action	Regression models are used to measure the impact of associative participation of individuals on their income level (NEVES; HELAL, 2007) or to measure the impact of parent-child relationships on academic performance (COLEMAN, 1988).	Investigations regarding either the structural autonomy of actors, structural holes and brokers (BURT, 2005) or regarding the mobilization of resources and emotional support by individuals embedded in social networks (LIN, 2005).
Maximalist social action	World Values Survey (INGLEHART 2008). Correlations between variables of civic community (PUTNAM, 1996). Barometers of social capital (SUDARSKY 2001).	The call by Ostrom and Ahn (2003) to construct theories of second-generation rationality and collective action. Studies on conversion of the relational capital of actors in lateral social control in collegiate organizations (LAZEGA, 2001, 2003).

Table 1 - Methodological typologies of social capital
Source: Salej Higgins (2012).

Coleman (1988)'s work on intra-family social capital are placed in the upper left quadrant because parents are making an investment in dense social relationships for the academic success of their children. To test his hypothesis, Coleman (1988) used logistic regression models. The reference studies on civic associations conducted by Putnam (1996) and his followers (SUDARSKY, 2001) are placed in the lower left quadrant because their studies sought to explain the engagement of citizens in solving common problems and to unravel the horizontal mechanisms of overcoming dilemmas of collective action. We place methodological advances in understanding the operation of horizontal participation

mechanisms in the lower right quadrant; these studies include those of Lazega (1998, 2001) that applied social network analysis to the domain of knowledge-intensive collegiate organizations to unravel the interaction processes that are important to organizational cohesion and efficiency.

The issue being analyzed in the present study is located in the upper right quadrant of this table. Several studies have been made that may be included in this quadrant. Lin (2005) researched how individuals can mobilize advantages, resources and emotional support from their networks of relationships. Ronald Burt (1995, 2000, 2005) went further in his research and identified the types of relational structures that facilitate an individual's undertaking of strategic action to gain some benefit – in particular, access to useful information. Burt developed the following three operational concepts: (a) structural autonomy, or the degree of pressure and limitation sustained by an actor with respect to his peers within a network of relationships; (b) the structural hole, or the low-density relational sector in which an actor is in the position of obtaining non-redundant information; and (c) the position occupied by a broker or actor that is a bridge between two denser sectors within a social network that enables the actor to obtain richer and more privileged information in advance or to stop information flows that are not convenient for him/her.

3 THE TWO HYPOTHESES OF SOCIAL CAPITAL

From the standpoint of neo-structural sociology (LAZEGA, 1998) – better known as network analysis – the fundamental insights of Bourdieu (1980) and Coleman (1988) were operationalized in the form of two well-established hypotheses (BURT, 1999; GODECHOT; MARIOT, 2004). First hypothesis: closed, stable and dense relational structures operate as a resource that facilitates the creation of social norms and interpersonal trust and the circulation of information, which is consistent with the hypothesis of density or closure postulated by Coleman (1988). A cohesive group will perform better in intergroup competition.
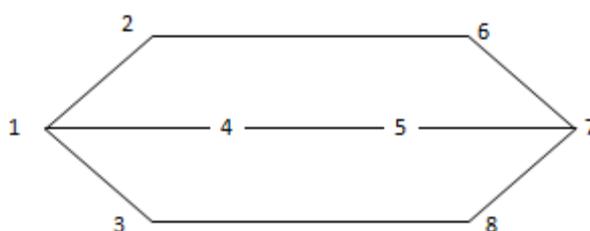

Figure 1 - Density hypothesis
Source: Klovdahl's graph (1992).

Suppose the graph above represents the exchange system of a popular market. Network density means that any opportunistic action in node 1, such as paying with a bad check, is quickly known by node 7. The diversity of relational paths from 1 through 2, 4 and 3 facilitates social control of opportunism.

Second hypothesis: open, diverse and porous structural relationships facilitate individual gain, according to the structural hole hypothesis postulated by Burt (1999). This hypothesis works based on the axiom that dense networks with redundant and strong ties degenerate information (GRANOVETTER, 1973).
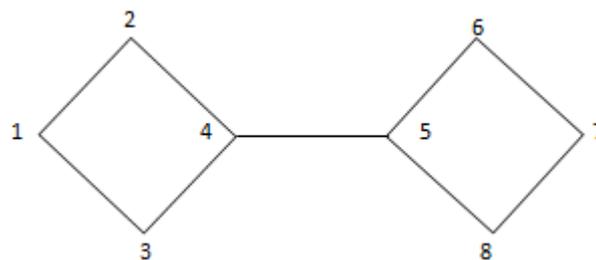

Figure 2 - Structural hole hypothesis
Source: Klovdahl's graph (1992).

Suppose the graph above represents the type of situation studied by Burt (1999), i.e., the complete network of friendship between managers of a large company. Node 5 (or broker 5) will be in a position to keep non-redundant information to himself/herself if useful information leaves the left sector of the network. Burt's analyses complement the fundamental finding of Granovetter (1973) regarding the strength of social ties. Weak ties are bridges, inter-network through which circulate not degenerate information. While Burt analyzes the lead within the structure, Granovetter (1973) describes the type of relationship.

The two types of network structures, corresponding to each hypothesis, are not necessarily mutually exclusive. They can work both ad intra and ad extra of a group structure. Burt (2000) builds topical following:

	Ad intra	
	Low density and cohesiveness	High density and cohesiveness
High redundancy of ties beyond the group	Minimum performance	Integrated group with a unique expertise, perspective and resource
Low redundancy of ties beyond the group	Group disintegrated with skills, perspectives and diverse resources	Maximum performance

*(left margin label: **Ad extra**)*

Table 2 - group Performance (Burt 2000).

4 METHODOLOGY

4.1 SOCIAL CAPITAL AND RELATIONAL STRUCTURES IN ACADEMIC LIFE

Godechot and Mariot (2004) reconstructed relational structures in doctoral education in French political science between 1990 and 2001. They analyzed the academic collaboration network between supervisors for the entire period of their study using the structure of the examination panel of the thesis. Their relational data is evidence of the effect of collegiate decision-making structures on academic careers. Godechot and Mariot (2004) tested the following general hypothesis with a relational universe of 741 doctoral dissertations:

The probability of the PhD student getting a job (y) is a function of the position of the director and committee members in the relational structure (x).

$$y = f(x) \qquad (1)$$

For the empirical test, Godechot and Mariot (2004) modeled the causal relationship through a logistic regression. In addition to the definitions of the descriptive variables that their data enabled (gender, nationality, degree-granting institution, sub-discipline of political science, etc.), we are interested in the explanatory variables of the relational structure. In the logistic model, the directors' and guests' network volumes (average number of contacts) and the *C* factor (or Burt's (2001) constraint) are disaggregated.

The calculation of *C* is performed in three stages. The number of contacts of *i* related to *j* is represented by z_{ij}. Burt initially measures the proportion (p_{iq}) of relationships that *i* invests in contact *q*:

$$p_{iq} = (z_{iq} + z_{qi})/\sum_{j \neq i}(z_{ij} + z_{ji}) \qquad (2)$$

The constraint of *j* on *i* is then calculated, i.e., the sum of his/her direct and indirect contacts:

$$c_{ij} = \left[p_{iq} + \sum_{q \neq i,j} p_{iq} p_{qj} \right]^2 \qquad (3)$$

Finally, the constraint C that the network exerts on i is the sum of all c from each of his/her contacts:

$$C_i = \sum_j c_{ij} \qquad (4)$$

C_i equals 1 when i has a single contact and approaches 0 when i's contacts are numerous and not very interconnected. However, the C index is much more complex because it condenses three dimensions of a network structure – density, size and hierarchy. Burt (1995) believes that the constraint is a function of the following three dimensions:

$$C = f(size, density\ and\ hierarchy)$$

From the empirical analysis of Burt (1995), may be typified in terms of correlation, how the dimensions affect the index:

		Constraint
Size	Big	Small (-)
	Small	Big (-)
Density	Big	Big (+)
	Small	Small (+)
Hierarchy	Muita	Big (+)
	Pouca	Small (+)

Table 3 - Correlation between C and its components (Burt 1995).

In sociological terms, a major constraint reduces the alternative contacts through which an ego may get new and useful information. Thus, highly dense and hierarchical networks reduce alternativity ties and increase the redundancy of the same.

The present study followed the work of Godechot and Mariot (2004); it used information from the accounting sciences discipline in Brazil at the post-graduate level. A network of academic collaboration was constructed from relational co-authorship data. In our case, we tested the correlation between scientific co-authorship and productivity of faculty members and also sought to assess the presence of a mechanism acting on the network's functioning, unlike the French researchers. We took a minimalist approach in the present study because we were interested in learning how individuals gained advantages in the academic environment.

4.2 DATA COLLECTION

The resumes found on the Lattes platform of the National Counsel of Technological and Scientific Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq) for all faculty members of *stricto sensu* postgraduate programs in the accounting sciences in Brazil were analyzed. We decided to use the entire population because it made the analysis of complete networks possible. However, it is noteworthy that one of the limitations of the data collection using the *Lattes* platform is that the platform relies on the researchers themselves to keep the information current. Thus, to minimize problems with updates, all resumes were downloaded on the same date: 12/30/2010. In addition, only resumes that had been updated up to 12/31/2009 were included in the present study; professors who had not changed their data by that date were not included in the database.

Another factor that must be considered when using a *Lattes* resume is the accuracy of its information because such information is the sole responsibility of the person who entered it. This may encourage the reliability of the data because the *Lattes* resume represents the professional, academic and scientific profile of the faculty member, and it is therefore in that person's interest that the information is reliable and well evidenced. The time span covered by our study was nine years (2002-2010). We constructed a database of articles published in scientific journals in the field of accounting sciences.

A description of the data collection and processing stages is shown in Table 4.

	Data sources	**Procedures**
Stage 1	Survey of the faculty body.	Analysis of the number and affiliations of faculty members connected with the studied programs.
Stage 2	Compilation of data extracted from the faculty members' resumes contained in the CNPq *Lattes* database.	Organization of the positional elements of individuals whose characteristics were analyzed.
Stage 3	Profile of programs and faculty body.	Analysis of characteristics collected in the previous stage to define academic and scientific profiles of both the programs and the faculty members who were the objects of the analysis.
Stage 4	Cooperation networks between faculty members of the programs.	Analysis of network morphology .
Stage 5	Analysis of the dynamics of the construction of scientific knowledge in the field of accounting sciences.	Interpretation of the information collected in the previous stages.

Table 4 - Data collection and processing stages

We used Microsoft Excel ® 2007, Ucinet 6.0 (BORGATTI; EVERETT; FREEMAN, 2005) and Pajek (DE NOOY; MRVAR; BATAGELJ, 2011) for data analysis. Microsoft Excel ® 2007 was used to organize the data and generate the adjacency matrices that were fed

into Ucinet 6.0. The latter was used in the assembly and calculation of the structure of social networks formed by faculty members of *stricto sensu* post-graduate programs in accounting sciences. Pajek was used in the preparation of sociograms.

4.3.1 Data obtained - the faculty body

Initially, we collected the number and names of members who comprise the faculty bodies of all the *stricto sensu* post-graduate programs in accounting sciences in Brazil by visiting the websites of such programs. At this stage, 253 faculty members were identified with three belonging to two programs. In those three cases, the faculty members were deemed affiliated with the programs in which they were part of the permanent faculty body. Thus, 250 faculty members were considered from 18 *stricto sensu* post-graduate programs in accounting sciences in Brazil.

Next, we conducted a search for the resumes of these faculty members on the CNPq website. Information was found for all 250 faculty members, but the analysis was performed with information from only 241 of those faculty members because nine faculty members had not updated their resumes by the established cutoff date.

4.3.2 Co-authorship

Certain problems regarding the dates of the articles were considered. The first issue concerned the year of inception of the program to which the faculty member belonged; only articles that were published after the creation of the master or doctoral program in the applicable institution were collected.

The second issue referred to the individual's inclusion in the faculty body of the program (or programs) to which he/she was affiliated during the study period. Thus, data collection initiated at this stage of the study considered only the scientific and academic output of the faculty member after his/her entry onto a *stricto sensu* postgraduate program in accounting sciences.

In certain cases, faculty members migrated from one program to another in the three sub-periods analyzed (2002-2004, 2005-2007 and 2008-2010). When this occurred, the faculty member was considered to belong to the program in which he/she was included in the sub-period analyzed. When a faculty member changed programs in the middle of a three-year period (for example, if a faculty member migrated between 2002 and 2004), he/she was considered to belong to the program to which he/she was affiliated for the majority of the sub-

period. Table 5 shows an example of how were tabulated articles according to the date of emergence program and the teaching of the binding date to this course of master's or doctorate.

Teacher	2002-2004	2005-2007	2008-2010
MATINEZ, A. L.	It was not linked to any program.	2006-2007: Linked to Master UFBA	2008-2010: Linked to the master's and doctorate from FUCAPE
In this case, the scientific and academic activities that teachers were considered the UFBA program in 2006 and 2007; and from 2008 to 2010 FUCAPE.			

Table 5 - Example article that entered the study according to the date of emergence program and teaching of the binding date.

From these assumptions were collected via Lattes platform of the National Council for Scientific and Technological Development (CNPq), all articles published by faculty. repeated studies were excluded. It is noteworthy that in some cases there were discrepancies regarding the authors of the articles, that is, not a teaching curriculum were certain authors and other curriculum contained different teachers, for the same item. In this case, we tried to the article via the Internet and proceeded to the verification of the authors in their work.

From that moment it was found that there were still items that contained teachers who might not be in the search. As an example, an article coauthored between Geez, V. and Dalmácio, FZ, 2002, in which the second author only began to participate in a strict graduate program sensu in Accounting in 2009. In this case, Dalmácio, FZ it was removed from the article.

As the study aims to analyze the relationship between programs, only items with two or more teaching programs as co-authors were part of the sample. For example, an article that has three authors, and only one of them is teaching some stricto graduate program sensu in Accounting, was not included in the survey. The example explained above serves as a basis to explain this Question choice of items entered in the search. After removal of Dalmatius, F. Z., the article was written only with the Our V. and therefore, it was removed from the analysis.

After all the steps and composition of the sample articles criteria, came to the total of 455 that would be part of Social Network Analysis formed by the stricto sensu graduate programs in accounting between 2002 and 2010. Table 6 summarizes the stages of collection items.

Stage	Description	Final number of articles
1st	Collection of all articles, including repeated articles.	3442
2nd	Elimination of duplicate articles.	2890
3rd	Elimination of articles according to the criteria program inception date and entry of faculty members.	2132
4th	Elimination of articles that were not authored by two or more faculty members.	455

Table 6 - Description of co-authorship collection stages

4.3.3 Measuring productivity

After developing the co-authorship database, individual productivity was calculated for each faculty member. For this purpose, the *qualis* system of the Coordination of Improvement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES-BRAZIL) was used. CAPES is the body of the Brazilian Ministry of Education (Ministério da Educação) that regulates postgraduate programs. For each area of knowledge, the CAPES system classifies and assigns a category to the different scientific journals in which Brazilian researchers are published. Table 7 summarizes the scientific journals classification.

Table 7 - *Qualis* Classification of Journals in the Field of Accounting Sciences CAPES - Brazil -2010

Qualis journal	Score	Weighting factor (%)
A1	100	28.57
A2	80	22.86
B1	60	17.14
B2	50	14.29
B3	30	8.57
B4	20	5.71
B5	10	2.86
C	0	0

A standardized total productivity score was generated using the abovementioned criteria[1].

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[1]The standardized score was obtained in several steps. First, scores for each category (A1 to C) were weighed against a total of 350 possible points. This weighting factor appears in Table No. 1. Second, the maximum number of articles published by a single author in a given category was determined and the weighted factor in the first step was then divided by the maximum number of articles obtained in the second. Thus, a specific score for every article in each category was obtained. This number, the final score, made the scores of each author comparable because it took as a reference point the author with the largest number of articles in each category. Third, the total score for each author was calculated by multiplying the number of his/her articles in each category by the specific score obtained in the second step. Finally, the individual score was divided by 100 to express an order of magnitude between 0 and 1.

5 OVERVIEW OF ACCOUNTING SCIENCES IN BRAZIL

In Brazil, the scientific field of accounting is at an early stage, but we have observed a significant evolution of programs in accounting education and research that has contributed to the development of scientific knowledge and increased information exchanges between researchers. According to Leite Filho (2008), this development is because of a significant increase in the number of *stricto sensu* postgraduate programs (masters and doctorate) in accounting with a consequent growth in accounting science output.

Peleias et al. (2007) note that the emergence of these *stricto sensu* programs has contributed to an increase in research and scientific output in accounting sciences in Brazil and has consequently enhanced the presence of accounting studies at important Brazilian and international scientific events. Another advantage of the development of postgraduate programs in accounting has been the creation of specific events, such as the USP Conference on Controllership and Accounting (2000), the increased number of accounting studies published in journals and the creation of the National Association of Postgraduate Programs in Accounting (Associação Nacional dos Programas de Pós-Graduação em Contabilidade - ANPCONT) in 2006. All these factors contribute to the scientific development of accounting sciences. Figure 3 shows the evolution of the number of *stricto sensu* programs in Brazil.
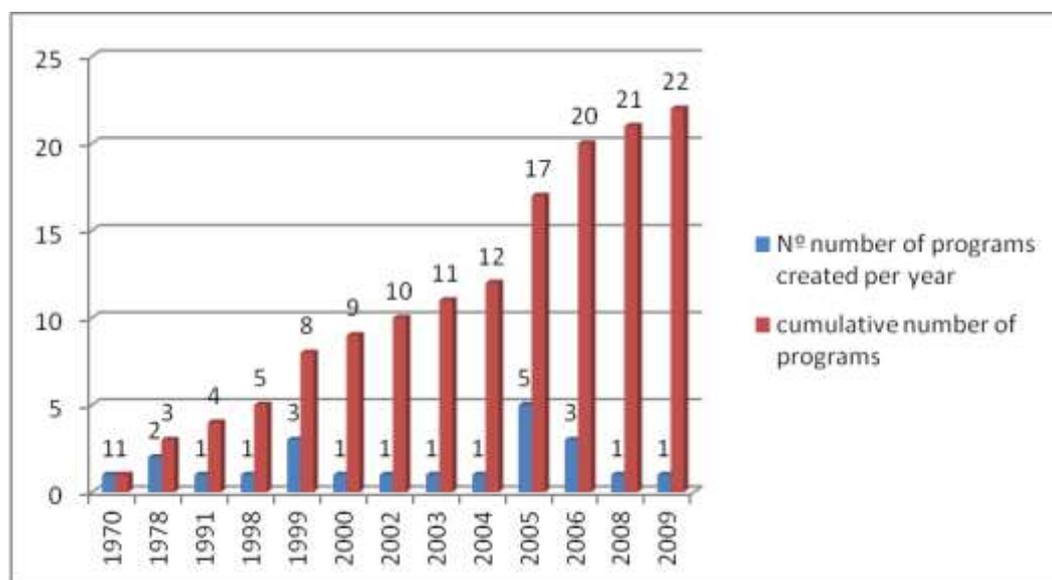

Figure 3 - Progression of the number of *stricto sensu* programs in Brazil

With respect to the scientific output – specifically, the publication of articles in journals – by the faculty of accounting sciences programs, it was found that faculty members' participation in this type of work grew significantly in Brazil over the period analyzed, as shown in Figure 4. It should be emphasized that all articles published by faculty members were included in this portion of the analysis on academic and scientific output, regardless of

the year in which they were published (with 2002 as the first year) or whether the work was co-authored with another faculty member.
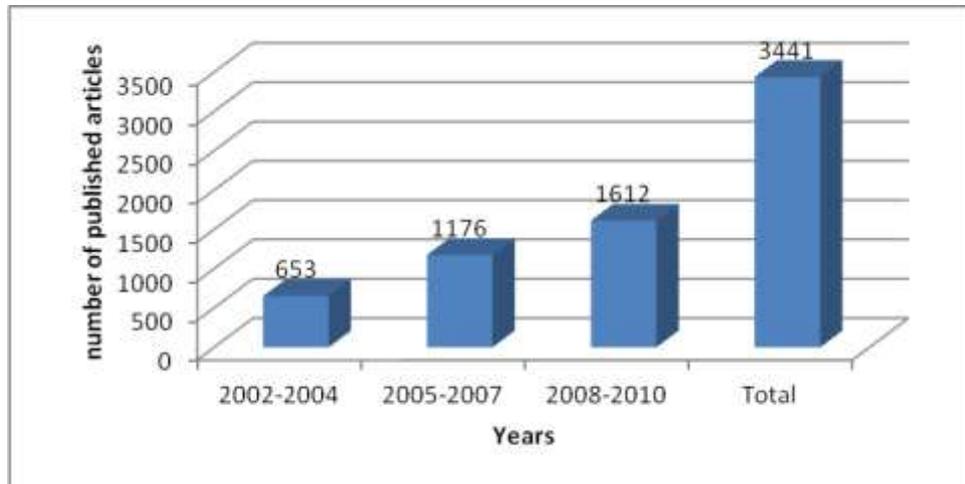

Figure 4 - Publication of articles by faculty members of *stricto sensu* postgraduate programs in accounting sciences in Brazil

From the first three-year period to the second three-year period, faculty members' participation in scientific articles increased by 80%, which coincided with the period of creation of seven Masters programs of accounting sciences in Brazil. Thus, it appears that the creation of the postgraduate programs stimulated scientific output in accounting and increased scientific cooperation through increased collaborations between faculty members, students and other researchers affiliated with the postgraduate programs. We evaluated the evolution of the number of authors per article from 2002 to 2010 (Figure 5).
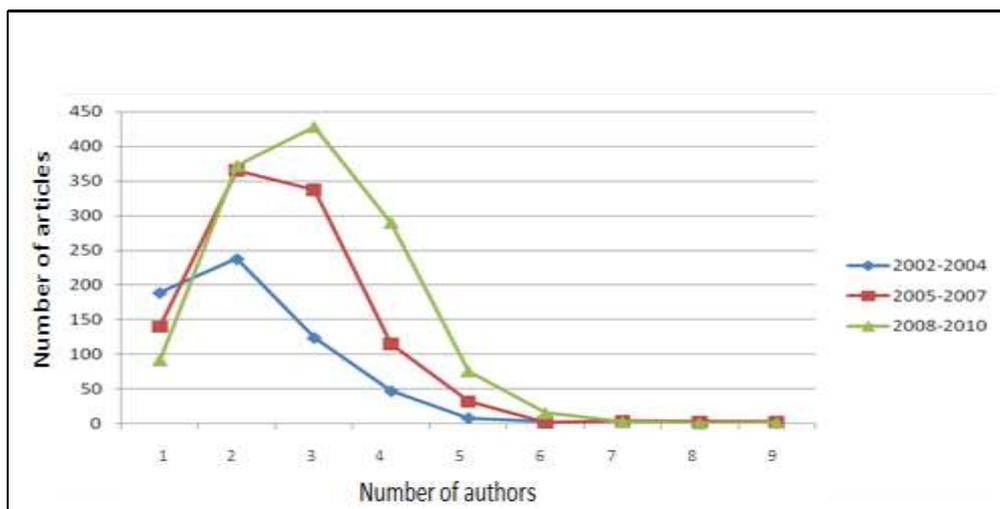

Figure 5 - Progression of the number of authors per article from 2002 to 2010

The number of articles with only one author decreased over the years. In the first period, 31% of the articles were produced by a single author. In the third period, between 2008 and 2010, only 7% of the articles had single authorship. Articles with two authors predominated in all three periods analyzed. It is notable that only studies with one author declined over the

period of the years analyzed, i.e., studies with two or more researchers increased, indicating that scientific collaboration is increasingly preferred by researchers over time.

These findings contrast with those of Cardoso et al. (2005), who analyzed the articles in the field of accounting sciences between 1990 and 2003 and found that only 41.66% of the articles were written by two researchers; most articles were written by one author (46.67%) during that period. Taken with the sample in this study, it appears that throughout the years, researchers in the field have become increasingly willing to collaborate when conducting scientific studies. Furthermore, the findings in our study corroborate the results of Cruz (2010), who aimed to identify the attributes of scientific output in the research field of management accounting in the triennium period from 2007-2009. Cruz (2010) research found that 92% of studies were prepared using a collaborative approach by analyzing 90 articles in the management field. The data show that co-authorship has become an important strategy in Brazilian accounting sciences. This finding reinforces the importance of understanding the mode of operation of the social network formed from this type of academic relationship.
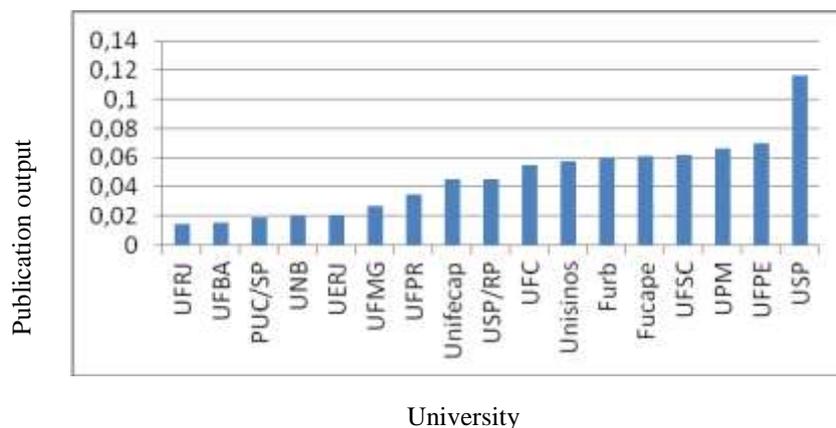

University

Figure 6 - Output in co-authorship by university in the period 2002-2010

6 STUDY HYPOTHESIS

The data show an academic context favorable to scientific output in the field of accounting in Brazil. However, despite the favorable scenario, it may yet be observed that certain actors perform better than others when the output of faculty members of postgraduate programs in accounting sciences is compared. How is this difference explained?

From a minimalist point of view, social capital is an essential explanatory factor. More productive individuals exploit their position – specifically, their structural autonomy – within the relational universe (BURT, 2000). This morphological property of the network constitutes an advantage that permits greater ownership of the resources in circulation. Thus, we might expect that the most productive authors in the field of Brazilian accounting sciences would

have a directly proportional relationship to their degree of structural autonomy within the network; the more productive authors will have lower C constraint factors within the network. Concretely, this means that the author at the edge of a structural hole may access more and better information that will encourage greater scientific productivity.

In the next section, we will analyze the structure of co-authorship relationships that has developed in the field of accounting sciences in Brazil.

7 THE SCIENTIFIC CO-AUTHORSHIP NETWORK IN ACCOUNTING SCIENCES IN BRAZIL

Table 8 shows descriptive statistics for the structures of relationships among the authors of articles published in co-authorship and their evolution during the analyzed period. Such information provides a better understanding of the development of the field and its relationships.

Table 8 - Descriptive Statistics of the Relational Structure of Co-Authored Articles

	2002-2010
Number of authors	176
Ties observed	311
Average number of ties per author	3.56
Degree of concentration of centrality (Degree)	6.04
Density	2.02%
Mean distance	5.18
Maximum distance (Diameter)	15
Clustering coefficient	0.39

Source: Study results

Table 5 shows that the analyzed network comprises 176 faculty members. Among these faculty members, 311 co-authorship ties were observed out of a potential total of 15,400 co-authorship ties. The ties indicate that two authors published at least one article in co-authorship – our study did not assign values to such relationships. Instead, we considered them as binary, i.e., as publishing in partnership or not, disregarding the number of repeated collaborations. On average, actors in the network exhibit 3.56 ties, which indicates good cohesion in the network and confirms that collaboration as a strategy in the production of an article is a characteristic of the studied field. The degree of concentration of centrality is 6.04%, which indicates that the structure of the network is not strongly hierarchical and that no author stands out as being central. The centrality of authors in the network varies between 1 and 14 collaborative ties. Of the 176 faculty members identified, 48 faculty members co-authored papers at least four times. These actors are at the center of the network and

contribute to the balance of power in the mapped universe. Figure 7 shows the structure of the Co-authorship Network mapped for publications in accounting sciences in Brazil from 2002 to 2010.
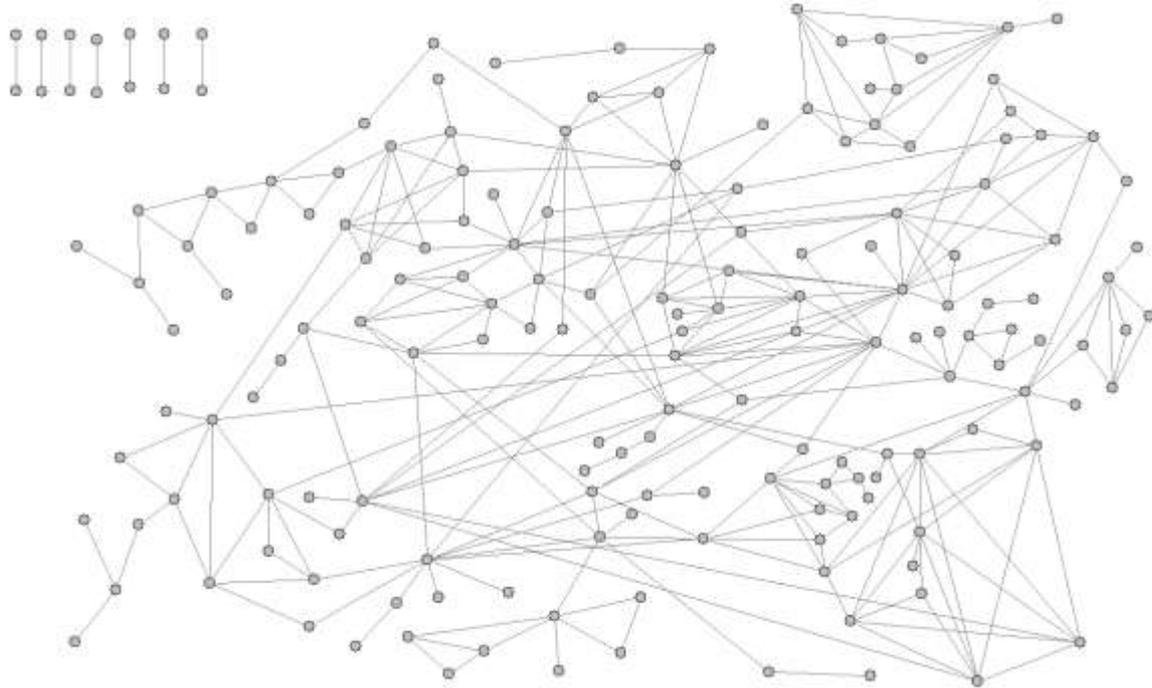

Figure 7 - Graph of co-authorship among faculty members of *stricto sensu* postgraduate programs in accounting sciences from 2002-2010 (Brazil)
Source: Study results

8 RESULTS OF THE ANALYSIS OF STRUCTURAL AUTONOMY

After calculating the scientific output for the entire 2002-2010 period, the structural autonomy (C factor) of each author in the co-authorship network was calculated[2]. The distribution of the two variables may be observed in the respective histograms. The opposite trend is suggested in the data distribution.

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[2] C factor analysis for the study case showed that the indicator displayed the expected behavior when correlated with other network dimensions that influenced it. The correlation between network size and constraint was negative ($R^2 = 0.78$). As for the density and hierarchy variables, these were found to be positively correlated with the C factor ($R^2 = 0.30$ and 0.85, respectively). Thus, the constraint value constitutes a good indicator of structural autonomy in the mapped network.
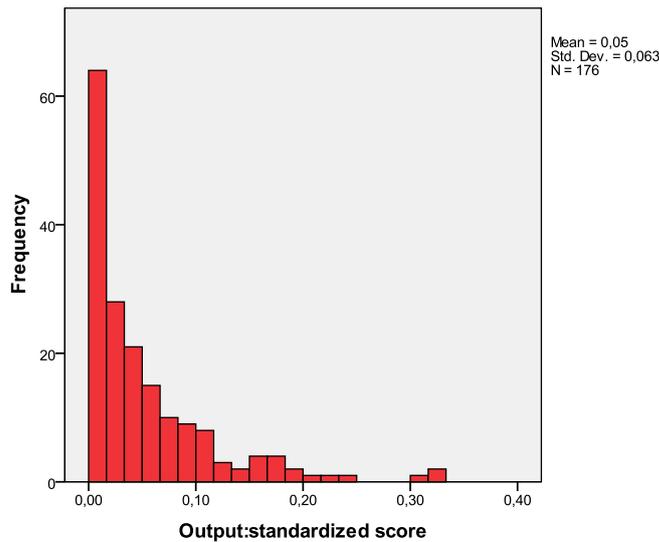
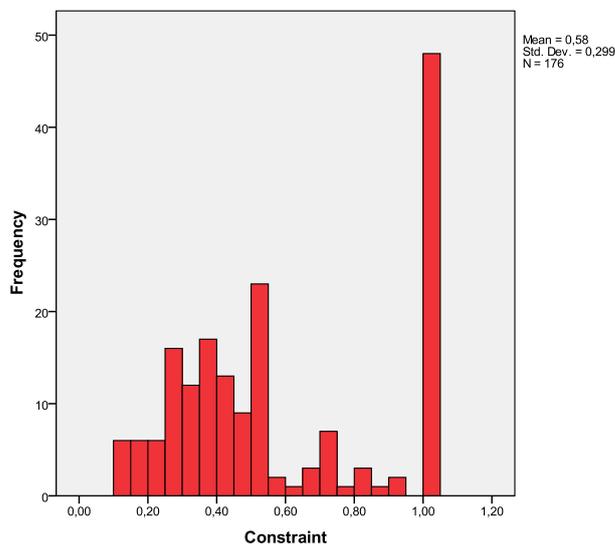Figure 8 - Distribution of output in *qualis* scores

Figure 9 - Distribution of structural autonomy or *C* constraint scores

Actors with a low-weighted score obtained the highest output frequencies (Figure 8), with more than 80% attaining a score that did not exceed a standardized value of 5%. Conversely, the opposite trend occurs for the structural autonomy index (Figure 9), i.e., almost 50% of the members display a value of 1, which is the maximum value possible. High *C* index values indicate low structural autonomy. The authors refer to nodes in positions that offer little chance to exploit the circulation of resources or information.

The data were found to support Burt's hypothesis when testing the correlation between output and constraint. The nodes with higher structural autonomy, i.e., those with lower C values, display higher output values. Figure 10 shows inverse function between the two variables. A constant (-0.009) and Beta coefficient (0.026) at a 99% significance level was observed. The determination coefficient, R^2 (0.434), was considered a modest result.
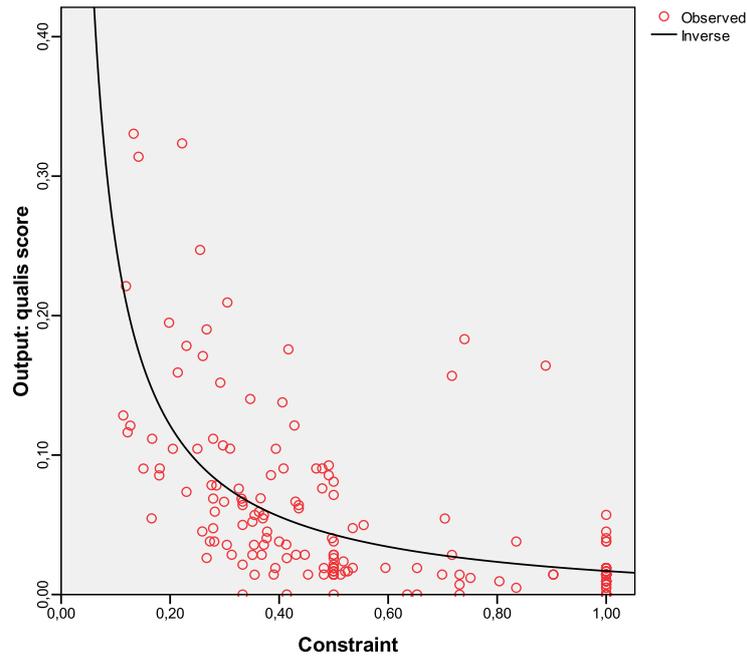
Figure 10 - Scatterplot of inverse relation between constraint and output

Figure 11 shows a graph with structural autonomy scores represented by point size (smaller points indicate greater autonomy). The three different time periods in which the author might have joined the network are shown in different colors. Authors who were on the network since 2002 and between 2002 and 2004 are indicated with darker points. Those who joined between 2005 and 2008 are represented in medium gray. Those who entered the network after 2008 are represented by the lighter points.
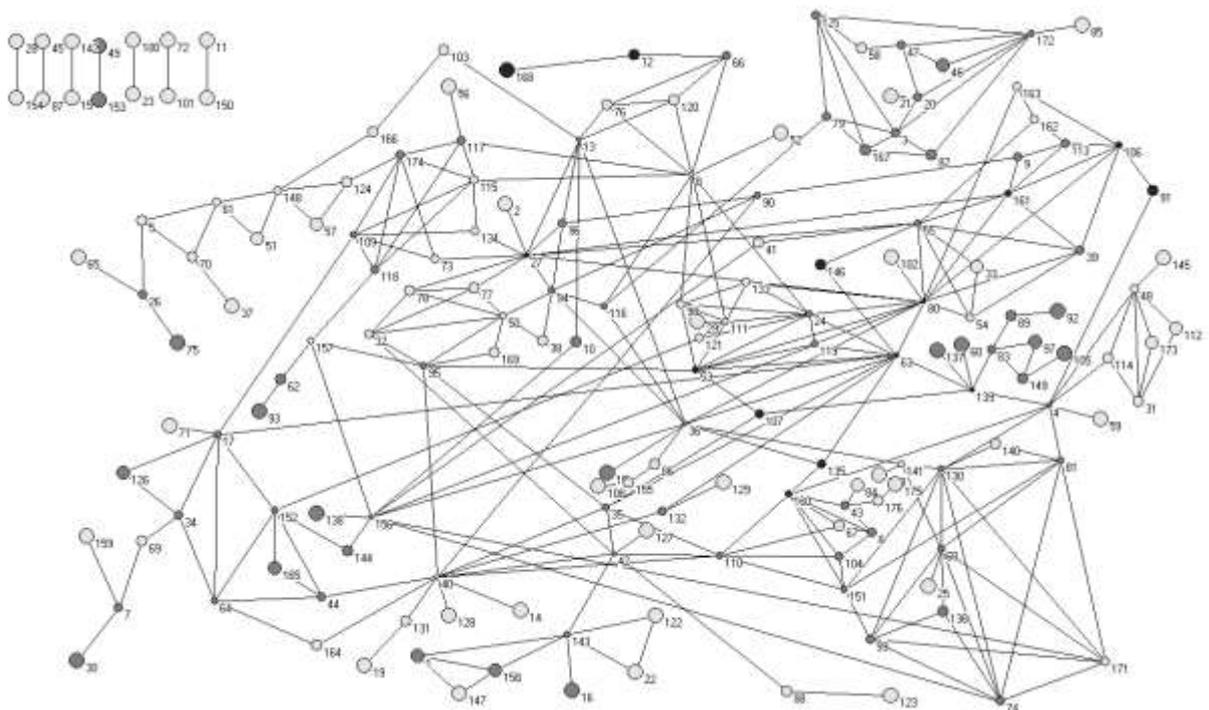

Figure 11 - Co-authorship network - Brokers, nodes with lower C scores x date entering the network

The sociogram shows the brokers in the network as smaller points, i.e., nodes with higher structural autonomy. These faculty members occupy the best positions for taking advantage of non-redundant information or resources circulating in the network. This morphological advantage from the point of view of the network structure is associated with higher productivity, as may be observed in the correlations presented in Figure 11 above. The graph also suggests that the length of time in the network is a variable that may be associated with productivity. To assess this trend, a new sociogram in which the size of the points represents output was developed (Figure 12).
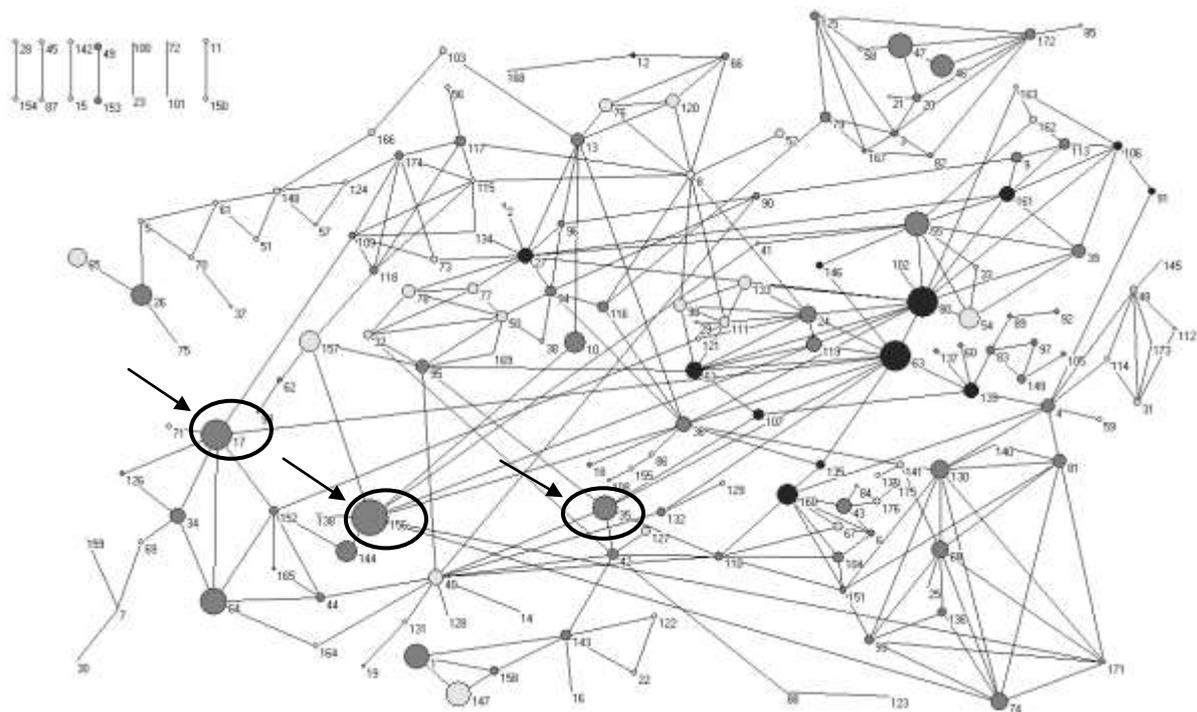

Figure 12 - Co-authorship network - Productivity x length of time in network

When the two representations of the co-authorship network were compared, productivity appeared to correlate better with the C constraint than with length of time on the network. It is noteworthy that actors joining after 2005 were as productive as authors who were on the network since 2002. Thus, the effect of seniority in entering the network appears smaller than might have been expected. The position of the actor in the network is an important variable, which is consistent with the Structural Hole theory. For example, actors 156, 17 and 35 joined in 2005 and have low constraint and high productivity. Thus, length of time in the network may be more relevant simply in explaining the poor performance of new faculty members who have not yet succeeded in colonizing the holes in the network.

9 LONGITUDINAL SELECTIVITY

Although length of time in the network does not appear to be directly correlated with productivity, the data suggest that seniority may be helpful in explaining the relational position of authors who only recently joined the network. The entry of such faculty members into the co-authorship network seems to show a selectivity bias that precludes them from developing a stock of social capital that they can use to gain structural autonomy in the mapped universe. Figure 13 shows how the relational patterns in the study case are affected by length of time in the network.
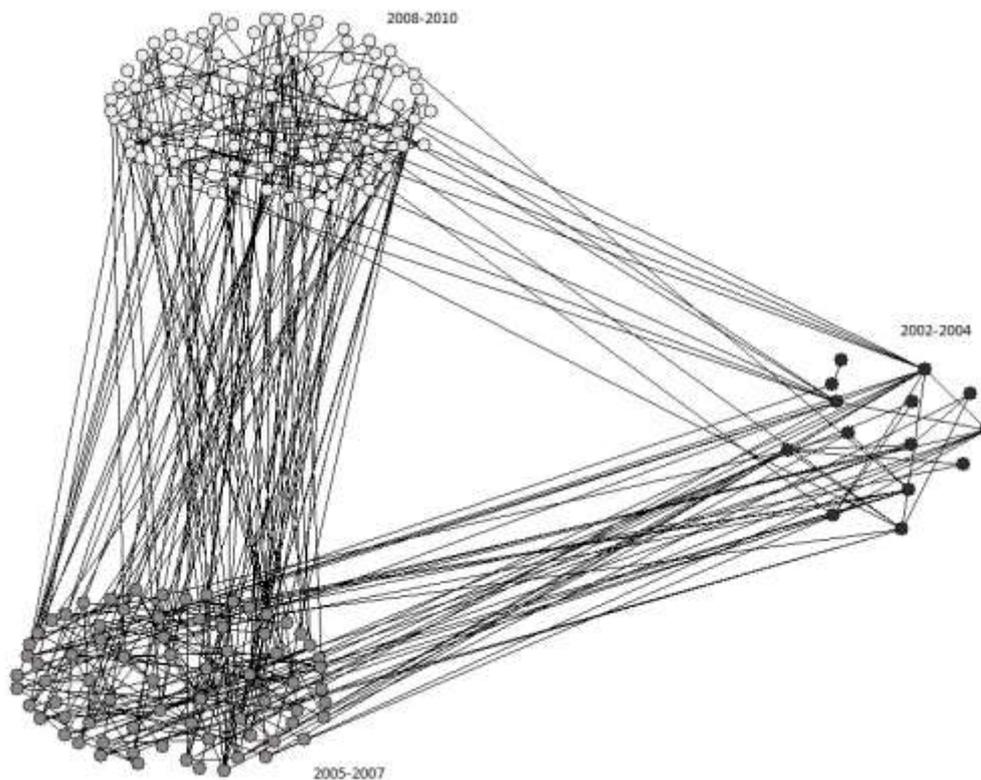

Figure 13 - Co-authorship network – Co-authorship relationships x length of time in the network

It may be observed that older members sought partnerships primarily with those who became faculty members between 2005 and 2007. In turn, more recent faculty members – those who joined the network since 2008 – have developed more relationships with faculty members who joined since 2005. Based on this hypothesis, we suggest that the network seems to operate under the pressure of a selectivity mechanism involved in the formation of partnerships. The length of time in the network seems to generate a relational pattern in which authors who recently joined the faculty ranks are received by the intermediate group, whereas the more senior faculty authors prefer to establish relationships with the intermediate group and, in some cases, select certain new faculty members as partners. Under this logic, faculty members with greater autonomy would exploit the structural advantages arising from their

position in the network to select the best partners for achieving high-quality output and to access non-redundant information.

Considering the findings presented herein, we must determine whether the network's selectivity bias operates only in relation to length of time in the network or whether there are other manifestations of the selection mechanism. We must investigate whether there is any tendency for co-authors to privilege certain relationships within the various programs, and a homophily analysis was therefore conducted for the study case. The results are presented in the next section.

10 HOMOPHILIC SELECTIVITY

The analysis of homophily helps to determine whether there was endogamy in the coauthors' publications, i.e., whether members of the same programs published in partnership. In general, strong endogamy is seen as a weakness because, on the one hand, it would indicate homogenized research interests; on the other hand, it would reveal the influence of somewhat biased and non-meritocratic selection criteria. The analysis of homophily reveals whether there is a tendency to build authoring ties with nodes that share the same affiliation because homophily is a criterion that makes relational choices selectively in the co-authorship network.

We analyzed the selectivity bias that operates in the network through an analysis of homophily that was based on the length of time in the network and the institutional affiliation of faculty members. We conducted a specific test, the *Relational Contingency Table Analysis - Directed Networks/Undirected Model*, to determine whether faculty members that were grouped according to length of time in the network tended to develop relationships between themselves or with members who joined at other times. Furthermore, we sought to determine whether the relationships among program faculty members have a tendency towards endogamy or not. The tables below show the test results, which were statistically significant in both areas. The tendency towards inter- or intra-group relationships is established by values greater than 1. These values indicate that the relationships observed in the network exceed the expected number. The diagonal of the table shows the tendency towards intra-group relationships, whereas an analysis of the rows reveals the relationships between one group and the others.

The first test in the studied network showed that there is a trend towards homophily among faculty members who were in the group that dated from the beginning of the period studied (the 2002 group). A trend among these authors towards co-authorship with the

intermediate group (the 2005 group) was also identified. As expected, the 2002 faculty members do not show a trend of maintaining relationships with the most recent group. Our test shows that the 2008 group tends to produce in co-authorship with members of the same group. With respect to authors who have joined the network since 2005, there is a tendency to produce work in collaboration with faculty members within the same category, in addition to a tendency to interact with the more senior faculty members. We believe that this test reinforces the argument about the selective bias of length of time within the mapped network.

Table 9 - Trends in Relationships Between entry Groups (Year of Entry)

	Year of entry		
	2002	2005	2008
2002	11,17	1,2	0,34
2005	1,2	2,28	0,41
2008	0,34	0,41	1,01

Observed Chi-squared value = 524.410
Significance = 0.000100
Number of iterations = 10000
Source: Study results

The second test performed showed that selectivity in the network also operates from the dynamic endogamy of the programs. A specific test, the *E-Index,* was applied to detect whether intra-institutional relationships were more common than inter-institutional ones in the studied co-authorship network. The index counts the intra- and inter-group ties then subtracts the total intra-group ties from the inter-group ones and divides by the total number of ties. The results range from -1, perfect homophily, and +1, perfect heterophily. The nodes were grouped into 17 different categories, corresponding to the 17 universities with which the authors were affiliated.

Table 10 - *E-I Index* for adjudication of intra-institutional and inter-institutional the network co-authoring (2002-2010)

	Obs	Min	Avg	Max	SD	P ≥ ob	P ≤ ob
Internal	0,601	0,019	0,061	0,119	0,013	0	1
External	0,399	0,881	0,939	0,981	0,013	1	0
E-I	-0,203	0,762	0,878	0,961	0,027	1	0

Note: E-I *Index* is significant $p < 0,05$
Source: Study results

Table 11 shows that the major co-authorship trends occur between faculty members of the same program (diagonal vertices of the matrix). However, this trend is not followed by certain faculty members who tend to establish relationships with authors from other programs.

Table 11 - Trends of Relationships Between Accounting Programs

	Fucape	Furb	PUC/SP	UERJ	UFBA	UFC	UFMG	UFPE	UFPR	UFRJ	UFSC	UNB	Unifecap	Unisinos	UPM	USP	USP/RP
Fucape	14,99	0	0,37	0	0	0	0	0	0	0,43	0	0,17	0	0	0	1,16	0,47
Furb	0	8,72	0,34	0	0	0	1,19	0	0,53	0	0	0	0	0	0,26	0,48	0,22
PUC/SP	0,37	0,34	2,95	0	0	0	0	0	0	0	0	0,29	2,01	0,49	0,49	0,88	0
UERJ	0,32	0	0	0	0	0	0	1,05	0	0,64	0	0	0,7	0,86	0	0,39	0
UFBA	0	0	0	20,62	20,62	0	0	0	0	0	0	0	0,94	0	0	0,52	0
UFC	0	0	0	0	0	11,1	0,3	0	0	0	0,43	0	0	0,26	0	0,48	0,22
UFMG	0	1,19	0	0	0	0,3	11,04	0	0,86	0	0	0,26	0	0,43	0	0,39	1,41
UFPE	0	0	0	1,05	0	0	0	25,86	0,62	0	0	0	0	0	0	0,42	0
UFPR	0	0,53	0	0	0	0	0,86	0,62	18,9	0,57	0	0	0	0,38	0	0,17	0
UFRJ	0,43	0	0	0,64	0	0	0	0	0,57	8,25	0	0	0,47	0	0	0,52	0
UFSC	0	0	0	0	0	0,43	0	0	0	0	21,37	0,19	0	0	0	0	0
UNB	0,17	0	0,29	0	0	0	0,26	0	0	0	0,19	4,71	0,19	0	0,23	0,62	0,37
Unifecap	0	0	2,01	0,7	0	0	0	0	0	0,47	0	0,19	13,49	0,94	0,62	0,14	0,51
Unisinos	0	0	0,49	0,86	0,26	0,26	0,43	0	0,38	0	0	0	0,94	18,9	0	0,34	0
UPM	0	0,26	0,49	0	0	0	0	0	0	0	0	0,23	0,92	0	22,33	1,55	1,25
USP	1,16	0,48	0,88	0,39	0,48	0,48	0,39	0,42	0,17	0,52	0	0,62	0,14	0,34	1,55	9,44	1,12
USP/RP	0,47	0,22	0	0	0,22	0,22	1,41	0	0	0	0	0,37	0,51	0	1,25	1,12	5,62

Observed Chi-squared value = 5352.436
Significance = 0.000100
Number of iterations = 10000
Source: Study results

Figure 14 shows the trend towards endogamy in the mapped network. Those authors linked to program 11 are easily distinguished in the top right corner, for example. The subgroup of program 1 is also distinct on the right side of the figure, as are those of programs 8 and 14 in the lower right corner. Program 6 in the middle lower section and programs 2 and 7 (to the left of program 6) also stand out.
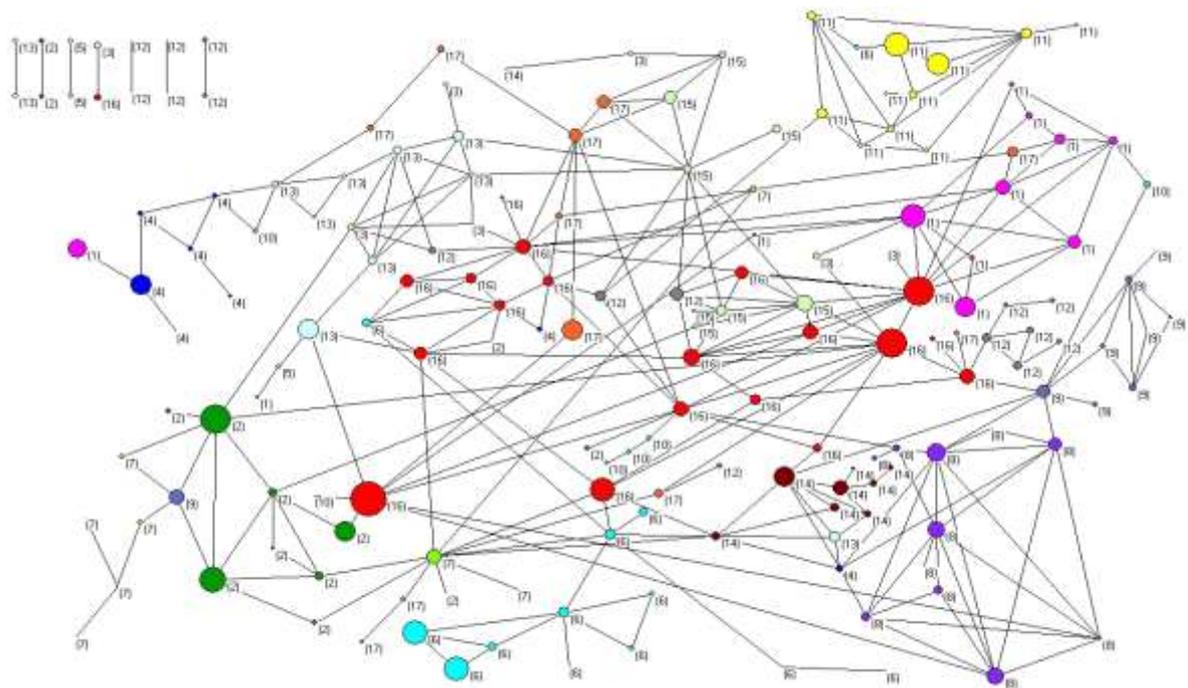

Figure 14 - Co-authorship network - Productivity x postgraduate programs

Although faculty members of program 16 have shown a tendency towards internal relationships, the graph above also shows that they are more scattered over the network, indicating that these faculty members establish relationships with faculty members from other institutions. It is plausible that this strategy promotes the productivity of these faculty members because they have more structural autonomy in the studied field.

11 PROGRAM SELECTIVITY FROM THE STANDPOINT OF COHESIVE SUBGROUPS

Network selectivity that is based on institutional affiliation criteria may be confirmed from an analysis of the subgroups of cliques *n*-5 and *n*-4. Cliques are network subgroups with densities equal to 100%; therefore, all members in these subgroups have relationships with each other. A *n*-5 clique indicates a diameter $d = 5$, i.e., the maximum geodesic in the subgroup is formed by five ties. The incorporation of this approach in the present paper aimed to identify whether the network's more restricted subgroups are formed within programs or whether they are open to external actors. Is institutional selectivity in its more rigid manifestation present in the studied network? We expect to find *n*-4 and *n*-5 cliques formed within the postgraduate programs if the response to this question is positive.

Three *n*-5 subgroups were found (Figure 12). Two of these subgroups were formed within the same institution (light gray). The third *n*-5 subgroup displays the same endogamic tendencies but incorporated an author from another institution. This third clique is within institution 16 (dark gray), which may explain the incorporation of an external actor; it is most likely the result of the relational pattern of faculty members in this institution because they value external and internal ties.

A third attribute was incorporated in the analysis to assess whether output quality constitutes a third selection bias in the network, in addition to temporal and institutional selectivities. Good productivity was defined as an actor publishing at least one article in an A2 journal or 3 articles in a B1 journal. For the representation of cliques, the square shape was used to represent the highest quality and the circle represented the lowest quality.

Focusing on output quality, we note that the clique of institution 16 involves authors with publications in high-quality journals. In the cliques of institution 8, publications were made in journals with a maximum CAPES qualis level of B2. The clique *n*-5 approach reinforces the notion of homophily and institutional selectivity in the network. It is notable that the strongest cliques in the network were formed within two programs. In addition, there are ties between authors who publish at the same quality level.
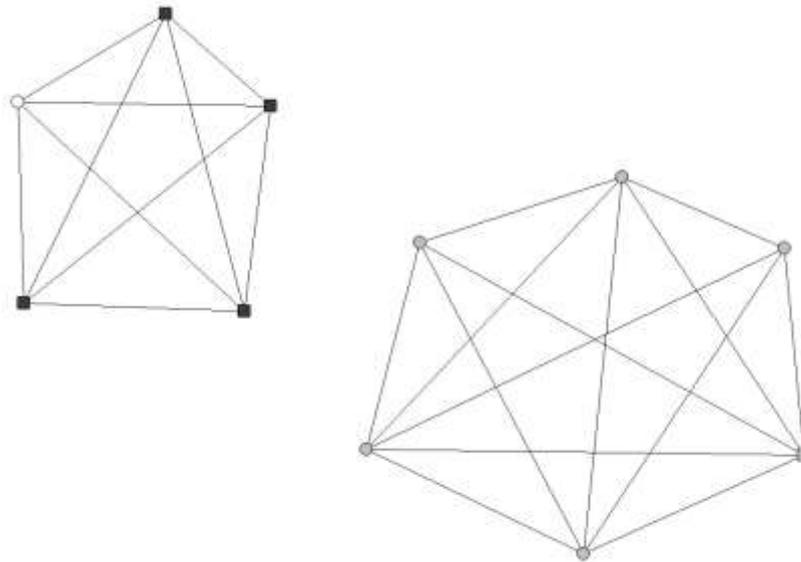
Figure 15 - Clique *n*-5 x postgraduate program and output quality

We identified 18 subgroups that met the requirements of *n*-4 cliques. The structure shown in Figure 16 provides further evidence of institutional selectivity. As was the case in the *n*-5 clique approach, the existence of cliques in certain programs is found. Authors from institution 8 are highlighted in yellow, those from 11 are light green, those from 1 are dark blue, those from 13 are purple and those from 15 are light blue. The data show that these institutions have greater internal cohesion regarding the co-production of articles. Another aspect that may be highlighted is the relational strategy of the authors of institution 16, which are highlighted in red. These actors are not only involved in cliques within their program but they have developed partnerships with faculty members at other institutions. The red actor no. 80 is the main communication gateway of the blue 4-clique with the other cliques. This actor has high productivity, having co-authored 14 published articles. This privileged position might be undercut with the emergence of another actor at institution 16 who began to operate as an alternative broker for the blue sub-group.
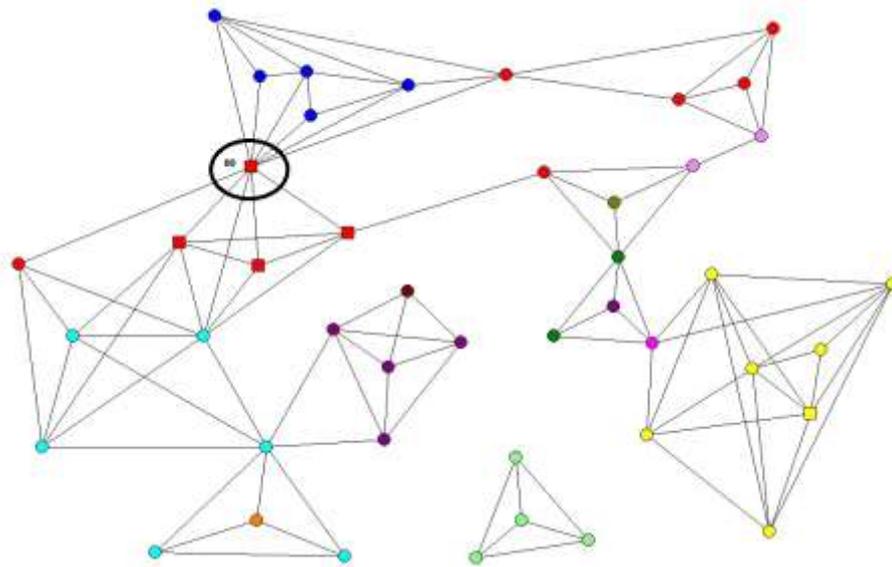
Figure 16 - *n*-4 Clique x postgraduate program and output quality

Regarding output quality, the *n*-4 clique analysis reinforces evidence of the operation of another selective mechanism in the network; Figure 16 shows that the cliques are composed of members with similar output quality. The impact of this output selectivity may be observed through Moran's autocorrelation. A highly significant moderate correlation of 0.548 was found for the mapped network (Table 12). This finding shows a relatively moderate tendency for adjacent members to display the same production, which may indicate the presence of a third form of selectivity in the network – output selectivity.

Table 12 - Autocorrelation of Network Selectivity (2002-2010)

Method	Moran
Permutations	1000
Random seed	695
Autocorrelation	0,548
Sgnificance	0
Permutation average	-0,005
Standard error	0,057
Proportion as large	0
Proportion as small	1

Note: Larger values indicate positive
Source: Study results

12 CONCLUSIONS

In the present study, we were able to confirm the hypothesis of structural autonomy. The data we analyzed showed that the productivity of faculty members in the co-authorship network of Brazilian accounting sciences is affected by the position they occupy in the network. Faculty members with fewer constraints, i.e., at the edges of the structural holes of the network, tend to be more productive.

In exploring the data, we found that there are several selective mechanisms behind the relationships in the mapped network, in addition to the advantages of structural autonomy. We show that there are at least three ways in which the formation of co-authorship partnerships are affected. First, we identified temporal selectivity that is related to the length of time that a faculty member has been in the network. We observed that this selective bias hinders the formation of faculty members' partnerships at the start of their career, i.e., for those who joined the network since 2008. A tendency to form cascading relationships was observed in which the youngest members establish relationships with intermediate members and the intermediate members establish relationships with older members.

Second, we found institutional selectivity. A tendency toward homophily was observed in the network, which is confirmed by the negative *E-index* and by the analyses of *n*-4 and *n*-5 cliques in the network. We found that actors generally select colleagues in their programs for co-authorship and that most cliques are formed within the same program.

Finally, output selectivity was identified as the third selective mechanism in the network. We observed that actors with higher productivity scores tend to be adjacent in the network, i.e., they tend to establish collaborations with each other.

There are several questions that remain open for further research, analysis and data development. In particular, two questions stand out. First, how does the co-authorship relational structure impact the scientific and professional recruitment of young teachers and researchers? Second, is there correlation between co-authorship and collaborative networks at the time of an MSc or PhD defense? These two questions require the extension of the longitudinality of the available data and the development of specific hypotheses regarding the accumulation of advantages and the building of strategies for scientific-academic career development. More robust longitudinal data will make SIENA (*simulation investigation for empirical social analysis,* SNIJDERS et al. 2007) analysis possible for a more precise understanding of how selection criteria change in networks of scientific and academic cooperation.

CONTRIBUTIONS BY THE AUTHORS

João Estevão Barbosa Neto contributed to the construction of the work as a whole, as well as the literature review, for data collection and data analysis.

Silvio Segundo Salej Higgins contributed to the construction of the work as a whole, the literature review and data analysis.

Jacqueline Veneroso Alves da Cunha contributed to the construction of the work as a whole, the literature review and data analysis.

Antônio Carlos Ribeiro contributed to the construction of the work as a whole, the literature review and data analysis.

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