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Deepening our understanding of academic inbreeding effects on research information exchange and scientific output: new insights for academic based research

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Abstract This paper analyzes the impact of academic inbreeding in relation to academic research, and proposes a new conceptual framework for its analysis. We find that mobility (or lack of) at the early research career stage is decisive in influencing academic behaviors and scientific productivity. Less mobile academics have more inward oriented information exchange dynamics and lower scientific productivity. The analysis also indicates that the information exchange and scientific productivity of academics that changed institutions only once do not differ substantially from that of "mobile inbred academics". This emphasizes the need for mobility throughout scientific and academic careers and calls for policies to curtail academic inbreeding.

Keywords Academic inbreeding · Mobility · Doctoral socialization · Academic profession · Information exchange dynamics · Scientific productivity

Introduction

A vast literature focusing on the university's contribution to global, national and regional systems of science, technology and innovation emerged as universities worldwide became important research and development (R&D) performers (Feller et al. 2002). Studies about academic mobility and collaboration, knowledge transfer mechanisms, industry-university partnerships, networks, modalities of funding, and scientific productivity became widespread (e.g., Breschi and Catalini 2010; Branco et al. 2010; Cruz-Castro and Sanz-Menéndez 2010; Evans 2010; Defazio et al. 2009; Boardman and Ponomariov 2009; Heinze et al. 2009), informing the policies created to foster universities' contribution to society. Despite the

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growth in research on academic work and outcomes, academic inbreeding (also known as institutional inbreeding), continues to be an understudied dimension. While its adverse effect on the scientific endeavor is frequently mentioned in reports, speeches, and opinion articles (e.g., Cyranoski 2002; European Commission 1995), there remains scant empirical research focused on this topic.

In his seminal work on graduate education in the US in the 1960s, Berelson (1960) defined academic inbreeding as a recruitment practice where universities hire their own doctoral students after graduation, who subsequently remain at the institution to work for their entire careers. The author stressed that academic inbreeding is closely associated with the concept of immobility, arguing that academics working at the same university where they held their doctoral degree but having previously worked at another university after concluding the doctorate could not be considered inbreds. He designated these as 'silver-corded faculty', underlining the relevance of mobility as a means of expanding their scholarly horizons due to exposure to different academic environments. Other authors, such as Caplow and McGee (1958) elaborated similar arguments, stressing that in opposition to inbreds, silver-corded scholars would be highly productive and competitive academics exactly because they proved themselves worthy elsewhere, securing the right to return to their Alma Mater. Few empirical analyses differentiate silver-corded academics from inbred academics, and the ones that do so, suffer from limitations (e.g., Wyer and Conrad 1984; Hargens and Farr 1973). In order to better understand the importance of mobility earlier in academic careers, the potential differences between inbreds and silver-corded faculty needs to be assessed. This is the first research aim of this article.

However, any recent analysis of academic inbreeding requires some degree of conceptual reformulation, since the latest and most accepted definition of academic inbreeding is the one given by Berelson in the 1960s. In the past 60 years substantial changes in science and higher education took place, in turn changing scientific and academic careers (see Hessels and Lente 2008; Frank and Gabler 2006; Altbach 2000, 2003). Therefore, the concept of academic inbreeding needs to be re-examined with respect to the above-mentioned changes, in order to give policymakers and university managers genuine insight into its impact. In this article, a reformulation of the inbreeding concept is advanced for critique. Finally, due to the perceived role of mobility in the creation of academic knowledge, we analyze if there are substantial differences in terms of scientific related communication and productivity among inbreds, silver-corded, and non-inbreds that moved only once from the university where they obtained the doctorate to the university where they are currently working. This aims at further extending the relevance of mobility in academia.

When performing any analysis on academic inbreeding, it is important to consider that the literature on the theme emerged in the US higher education system, at a time when the US academic research capacity was growing and academic inbreeding was perceived as a key problem (Caplow and McGee 1958). As the US higher education system evolved, academic inbreeding practices were disrupted and gradually, to this day, came to be viewed as an anomaly. However, high rates of academic inbreeding are prevalent in many developed and developing scientific systems throughout the world (Cruz-Castro and Sanz-Menéndez 2010; Yamanoi 2005; Bleiklie and Hostaker 2004; Navarro and Rivero 2001), and this practice is often perceived as being harmful for the development of developing/intermediate scientific systems (e.g., Smolentseva 2003; Padilla 2008; OECD 2007). The higher education systems of the latter countries have characteristics that differ substantially from the US higher education system where most academic inbreeding studies were performed. In these countries' higher education systems, the academic job market does not assume market characteristics, salaries tend to be regulated and do not vary substantially

among universities, faculty cannot or only in exceptional circumstances can negotiate their salaries, and closed recruitment practices and career advancement decisions are still observed (Perotti 2008; Padilla 2008).

In this regard, Portugal is an ideally suited country for the study of academic inbreeding. It is in a developing/intermediate stage of scientific development, comparable to other countries in similar (and lesser) stages of scientific development (Conceição and Heitor 2005). Portuguese universities have high rates of academic inbreeding, rigid organizational structures and career incentives, and are relatively non-responsive to societal challenges (Horta 2008). In the majority of universities, there is no salary differentiation of faculty based on merit; salary levels are fixed according to academic rank and number of years worked in each rank (Altbach 2000). The higher education system is characterized by very low levels of mobility across universities associated to implicit and explicit incentives for academics to remain at the universities where they perform academic activities (Soares and Trindade 2003). Although recruitment processes in Portuguese academia have been opening-up and decisions to hire candidates are increasingly based on merit, nepotism and other formal and informal barriers to open and meritocratic hiring still endure in a similarly fashion to other higher education systems (for an in-depth discussion see Perotti 2008). These characteristics led the OECD review of tertiary education in Portugal, to characterize Portuguese higher education institutions as "too academic and inward looking, resulting in a high degree of insularity and inbreeding" (OECD 2007: 146).

This study is organized as follows: section "Academic inbreeding: literature review and setting of the study" details the conceptual and empirical literature on academic inbreeding, which the empirical analysis draws upon. Section "Data and methods" describes the data used in the study, explains the explanatory variables, and specifies the models used to estimate the effects of the critical explanatory variables concerning scientific productivity and research information exchange dynamics. Section "Results" presents the results, while section "Discussion" explores the significance of the work. The conclusions and suggestions for future research are discussed in section "Conclusion".

Academic inbreeding: literature review and setting of the study

The literature on academic inbreeding follows two main perspectives: (1) the relationship between academic inbreeding and scientific productivity, and (2) the intellectual stagnation of inbred faculty associated with limited connectedness outside of the Alma Mater.

The first perspective has been most extensively studied. The first studies linking academic inbreeding to scientific productivity were two case studies of US universities (University of Chicago—Reeves et al. 1933; Indiana University—Hollingshead 1938) and two others performed at the system level (McNeely 1932; Eells and Cleveland 1935). The results from these studies are based on descriptive statistics, correlations, or both. These methods have remained the most common approach to test the relationship between academic inbreeding and scientific productivity throughout time. A more recent study of this type is a correlation analysis of inbreeding and scientific productivity of 51 European ecology or zoology departments (Soler 2001). With the exception of a single study, concerning the University of Texas, where a positive relationship between academic inbreeding and scientific productivity was found, the literature indicates that inbred academics have lower levels of achievement, when compared to their non-inbred counterparts (McGee 1960).

Hargens and Farr (1973) were the first to use regressions to assess the effects of inbreeding on scientific productivity. Their findings are consistent with previous research that found a negative relationship between academic inbreeding and scientific productivity. However, their study was limited by their focus on the scientific productivity of natural sciences scientists. Extending Hargens and Farr's (1973) work, Wyer and Conrad (1984) examined the relationship between institutional origin and productivity using a 1977 survey of the American professoriate that encompassed 160 institutions and all major academic disciplines. The authors found that, if adjustments for academic effort were included, inbred faculty would produce more than non-inbred faculty, contradicting previous research on academic inbreeding. However, in spite of adding effort variables (e.g., time spent in teaching) to the analysis, some control variables, such as gender, were absent. Only recently, a study using a wider range of control variables confirmed that inbreds produce fewer scientific outputs than non-inbreds, estimating that non-inbreds produced on average 15 % more scientific papers than inbreds (Horta et al. 2010).

Most empirical studies tend to use Berelson's concept of academic inbreeding. In the late 1950s, it was realized that to analyze the effects of academic inbreeding on scientific productivity, the concept of academic inbreeding required a precise definition. Immobility served as the key rationale to define academic inbreeding. Only those academics that remained in the university that granted their doctorate were considered inbreds (Caplow and McGee 1958; Berelson 1960). Academics that were currently working in the same university where they had obtained their doctoral degree, but had worked elsewhere after concluding the PhD, were termed "silver-corded". In their study of the US academic market, Caplow and McGee (1958) argued that silver-corded academics, unlike inbred academics, were expected to be scholarly superior and very competitive in the academic labor market. The assumption was that only by working at another university, and proving themselves outside the Alma Mater's supportive environment, were the academics deemed worthy to return.[1] This mobility worked as a 'quality test' of the recent graduates abilities and remains an ongoing practice at US research universities.

Only two studies attempted to test Caplow and McGee's (1958) proposition, with differing results. Hargens and Farr (1973) found silver-corded faculty to produce fewer scientific outputs than non-inbred faculty (except for the silver-corded faculty working at highly reputable departments), while Dutton (1980) found that the scientific productivity of silver-corded and non-inbred faculty was indistinguishable. In face of these mixed results, the understanding of how the production of scientific outputs differs among inbreds, non-inbreds and silver-corded academics is pursued in this study.

The second perspective regarding academic inbreeding concerns its characterization and how it may affect the development of scientific activities. This perspective posits that when universities hire their own doctoral students, there is a reproduction of learned knowledge, practices, and a consolidation of social structures (Yamanoi 2005). This occurs because inbreds mainly assimilate knowledge already contained in the institution, which, upon becoming faculty, they in turn use to inform their peers and future students (McNeely 1932). Their socialization is thus experienced in a relatively narrow framework that favors an institutional assimilation of beliefs, norms, and assumed behaviors rather than more

[1] It is important to note that in the US higher education system, the mobility of silver-corded academics is a process that can be associated with some kind of "sponsored" mobility with mutual expectations of return. This sort of mobility is not usual or expected in the Portuguese higher education system.

universal mindsets. In this context, Padilla (2008) found that in higher education systems with high rates of academic inbreeding, institutional loyalty has primacy over loyalty to the scientific field. In the context of organizational structuring, inbreeding is seen in a favorable light by some authors who argue that hiring inbreds reduces hiring searching processes, long-term retrenchment costs, the uncertainty of failure in the hiring decision (Bean et al. 1996), and permits an efficient use of human resources (McGee 1960) and knowledge (Camerer and Vepsalainen 1988).

Yet, other authors, such as Pelz and Andrews (1966), claim that these benefits are beset by a limited organizational knowledge scope, and flexibility that have the potential to negatively affect the development of academic activities. Pelz and Andrews (1966) stressed that the detrimental effects of inbreeding on scientific productivity exists because inbreds tend to favor internal information exchange, rather than communication with other educational, scientific and societal institutions. Recent empirical work tested this assumption, confirming that, in comparison with their non-inbred peers, inbreds prefer to exchange scholarly information within the university, which, in turn, leads to lower scientific productivity (Horta et al. 2010). These empirical findings established a link between the two main perspectives concerning academic inbreeding, yet omitted silver-corded faculty. Taking into account the arguments by Pelz and Andrews (1966) and the importance of mobility as a distinguishing factor differentiating inbreds from silver-corded, the information exchange behaviors of silver-corded, inbreds and non-inbreds is now analyzed.

As noted in the introduction, changing higher education and scientific systems requires conceptually reconsidering the nature of academic inbreeding. This is necessary to better frame the effects of academic inbreeding in terms of academic communication behaviors and productivity in contemporary science and higher education development. For the last six decades, both scientific and higher education systems have endured a long process of change, and with it, scientific and academic careers have changed substantially as well (Altbach 2003). These changes transformed the socialization from doctoral graduation to academic career entrance. Besides the growing emergence of joint and dual doctoral programs around the world, it is becoming increasingly common for doctoral students to spend research periods outside the universities where their doctoral degree is based, not only within the country, but also abroad (Kyvik et al. 1999). Also, performing a post-doctorate after obtaining the PhD (usually away from the university where the doctoral degree is granted) as a further investment in academic networking and knowledge acquirement, while dealing with increasingly constrained academic labor markets, is more frequent than ever (Stephan and Ma 2005).

These practices are related to increased inter-institutional mobility during the doctorate and also during the period between the doctorate and the first academic appointment, practices that were rarer when Berelson proposed his definition of academic inbreeding in the 1960s. Furthermore, recent empirical studies suggest that a postdoctorate experience positively affects research productivity and international connectedness later in a scientific career (Horta 2009). The fact that these changes are related to mobility (a critical element defining academic inbreeding) and occur at a time encompassing doctoral socialization and the first academic career appointment, made them critical for the analysis.

We acknowledge that various types of mobility exist in academia (Hoffman 2009). However, this analysis focuses primarily on geographic mobility as the key criteria, following Berelson's (1960) definition of academic inbreeding. With respect to geographic mobility, we propose that two categories of inbred academics have emerged: one

corresponds to inbred academics who have never performed research elsewhere, except at their own university, including during the doctorate degree and the post-doctoral period, thus designated as 'pure-inbreds'. The other category refers to inbred academics who have spent scholarly-focused periods of time elsewhere either during their doctoral education, their post-doctoral period or both, and are designated 'mobile-inbreds'. Because one category of inbreds is mobile, we expect that they will have different scientific related communication behaviors and productivity from the immobile category.

The growing perception that mobility is closely related to better research quality (Dillon 2003), and the increasing relevance of mobility within S&T systems merits attention (Dietz and Bozeman 2005). In this context, this analysis goes beyond the "traditional" problem of academic inbreeding itself, to analyze mobility from the viewpoint of the non-inbreds as well. Although non-inbreds spent time outside the university where they obtained the doctoral degree, many remain in the first university that hired them for the whole of their careers. The "one move only career" is typical of countries like Portugal with relatively static academic labor markets and where academic mobility is not the norm. This career implies that this segment of non-inbreds remains immobile after accepting their first academic position, resulting in careers that can be comparable to those of inbreds. In this context, Dutton argued that "many of the observations attributed directly to inbreeding may not be unique to inbreds but more pervasive and generally indicative of the less mobile segment of the academic community" (1980: 4).

Dutton was concerned with the declining academic mobility in the US higher education system, and examined the scientific productivity of non-inbreds who remained at a single university for their entire careers—which he designated as "adherents"—in contrast to that of inbreds. Through the use of regression analysis, he found that the scientific productivity of inbreds and adherents was markedly similar, suggesting that immobility negatively influenced productivity. In this study, Dutton's (1980) suggested hypothesis is tested in a country that, unlike the US academic labor market, has a static academic labor market.

To summarize, a brief description of the academic career categories to be analyzed in this study is presented in Table 1.

Table 1 Taxonomy of the academic career categories to be analyzed

Academic career categories	Explanation
Pure inbreds	Immobile. Inbreds that have always spent their learning and academic career in the same university
Mobile inbreds	Inbreds that have either spent a research or teaching spell at other university during the doctoral degree or did a post-doc at other university (or did both) before taking the first academic appointment at their Alma Mater
Silver-corded	Academics currently working in the same university where the doctoral degree was awarded, but started the academic career elsewhere after the completion of the doctoral degree
Adherents (non-inbreds)	Academics which moved only once in their academic careers: from the university that granted their PhD to the university that granted them their first academic appointment; These academics remained at the latter university throughout their academic career
Non-inbreds	Academics working in an university other than the one where the doctoral degree was awarded and worked on several universities during the academic career

Data and methods

Description of the data

The target population of this study is faculty holding a doctoral degree in 2008, from all scientific fields, and Portuguese universities that offered doctoral programs within the last 5 years. Basic information on the targeted population was provided by the *Gabinete de Planeamento, Estratégia, Avaliação e Relações Internacionais* (GPEARI), the statistics and planning department of the Portuguese Ministry of Science, Technology and Higher Education. The survey questioned academics about their educational and professional paths, as well as broad academic activities related to teaching, research and service. In this regard, several questions were asked regarding their engagement in research activities, research funding and its sources, number of students taught—at which education cycle, working habits, satisfaction levels, and academic and scientific production. The survey structure followed the format of previous surveys of the academic profession and working conditions, including the 1992 and 2008 surveys "Change in Academic Profession (CAP)".

An online survey was sent to more than seven thousand five hundred academics working in 18 higher education institutions in the fall of 2008, and obtained a response rate of 19 %, corresponding to 1,420 unique observations used to perform the analysis, and an error level of 2.3 % at the 95 % confidence level. The response rate is similar to that of recent survey exercises focusing on the academic profession, perceptions and behaviors (Bexley et al. 2011; Locke et al. 2011). While a low response rate could be problematic, studies demonstrate that datasets resulting from low response rates can yield more accurate measurements and quality than those with greater response rate levels (Krosnick 1999). This, complemented by the fact that the degree of generalizability of survey research is mostly understood in terms of the extent to which the sample is representative of the population of interest by having a similar set of key characteristics, makes representativeness more relevant than response rates (Cook et al. 2000). As shown in Table 2, the characteristics of the dataset represent a close fit with the distribution of faculty per higher education institution—the faculty proportion in HEI 4 is only slightly underrepresented—and the population regarding gender distribution, an important individual determinant of research productivity (Fox 2005).

Dependent variables

The analyses assessing research information exchange behaviors of silver-corded, inbred and non-inbred faculty are based on a research information exchange variable. This variable has been constructed using several questions included in the survey, such as: information exchange regarding thematic, theoretical and methodological developments found in specialized literature, funding sources for research and development projects, acquisition of laboratory equipment or software, access to bibliographic datasets and other databases, and the writing of scientific outputs. The survey inquired about the level of intensity of information exchange for two internal locations and two external locations. The two internal information exchange locations referred to the department to which the academic belonged and other academic departments within the university. The two external information exchange locations referred to colleagues based at national institutions and colleagues based at institutions outside the Portuguese higher education

Table 2 Representativeness of Survey Respondents to population by institutions and gender distribution (%)

Higher education institutions	Population	Sample	*T* test		
			Pr(Z < z)	Pr(|Z| < |z|)	Pr(Z > z)
Hei1	0.01	0.01	0.52	0.96	0.48
Hei2	0	0.01	0.45	0.89	0.55
Hei3	0.05	0.01	0.79	0.43	0.21
Hei4	0.11	0.07	0.92	0.17	0.08
Hei5	0.06	0.02	0.80	0.40	0.20
Hei6	0.11	0.12	0.33	0.66	0.67
Hei7	0.14	0.16	0.12	0.24	0.88
Hei8	0.1	0.1	0.40	0.81	0.60
Hei9	0.04	0.05	0.32	0.65	0.68
Hei10	0.03	0.03	0.45	0.91	0.55
Hei11	0.01	0.01	0.49	0.99	0.51
Hei12	0.01	0.01	0.48	0.96	0.52
Hei13	0.02	0.02	0.52	0.97	0.48
Hei14	0.16	0.15	0.56	0.89	0.44
Hei15	0.08	0.1	0.22	0.44	0.78
Hei16	0.03	0.04	0.34	0.68	0.66
Hei17	0.03	0.05	0.19	0.38	0.81
Hei18	0.02	0.03	0.37	0.75	0.63
Faculty (percentage of females)	0.37	0.39	0.22	0.44	0.78

The names of the universities are kept anonymous and referred at all times as higher education institutions (hei)

system. The information exchange intensity was measured for each question through the use of a Likert scale, where 1 (i.e., "never") refers to the minimum information intensity value, and 5 (i.e., "frequently") refers to the maximum information exchange intensity value.

Following Horta et al.'s (2010) methodology, in order to assess the location (internal vs. external) that academics favor for exchanging information on research topics, a scale was created based on the sum of the information exchange intensity of the two external locations, minus the sum of the information exchange intensity of the two internal locations. Therefore, the scale would range between −8, corresponding to the maximum internal information exchange, and 8, corresponding to the maximum external information exchange. The research information exchange variable refers to the average of results from all the survey questions related to research related practices. As shown in Table 3, on average, faculty tends to exchange more information within the university, something which is expected (see Bozeman and Corley 2004).

The scientific productivity variables are the number of doctoral theses supervised (this is a variable which combines elements of teaching and research) and the number of articles published in international and national peer-reviewed journals during the period between 2006 and 2008. The 3 year period referencing publications is widely sought in surveys focusing on academic careers and work and used in the literature to assess recent

Table 3 Descriptive statistics

Variable	Obs	Mean	SD
Information exchange variables			
External Research information Exchange	1.420	−1.05	1.57
Scholarly production variables			
Articles in international refereed journals	1.364	5.28	6.96
Articles in national refereed journals	1.342	2.40	4.19
Number of doctoral dissertations supervised	1.319	1.49	2.06
Explanatory variables			
Silver-corded	1.420	0.06	0.24
Pure_inbred	1.420	0.32	0.47
Mobile_inbred	1.420	0.26	0.44
Adherents	1.420	0.22	0.42
Control variables			
Age	1.418	46.66	7.68
Female	1,420	0.39	0.49
Had funded to perform R&D in the last 3 years	1.420	0.73	0.44
Participation in R&D projects in the last 3 years	1.420	0.90	0.31
Holds position at other institution	1.420	0.22	0.41
Administrative hours per week	1.314	2.61	3.19
Teaches graduate students only	1,420	0.04	0.19
Teaches undergraduate students only	1.420	0.12	0.32
Average number of students taught	1.420	193.19	208.89
Publications per career year	1.126	2.26	4.82
Natural sciences	1.420	0.35	0.48
Engineering	1,420	0.19	0.40
Agricultural sciences	1.420	0.04	0.20
Social sciences	1.420	0.24	0.43
Humanities	1.420	0.11	0.32

publication behavior.[2] It also serves to control for the effects of academic seniority, taking into account time lags between research work, submission and publication which are influenced by variables associated with current working behaviors and activities that can be measured through a survey exercise (Fox 2005). We asked about recent publications in national and international journals in order to address the expectation that inbreds have their research productivity oriented towards national-based journals (Birnbaum 2005; Shimbori 1981).

In this study, the analysis is based on self-reported data. The self-reported nature of the scientific productivity variables raises some validity risks, but recent methodological literature stresses that data on self-reported publications is more valid than often perceived (Chan 2009), that self-reported publications tend to be highly correlated with publications

[2] For example, the three year publication period is asked by the National Science Foundation, Survey of Recent Doctorates, and in the National Study of Postsecondary Faculty (NSOPF) by the National Center for Education Statistics survey.

found in bibliometric datasets (Clark and Centra 1985), and that the findings' consistency of studies on faculty, academic work and outputs over time lend validity to previous findings resulting from self-reported data (Jordan 1994). For these reasons, recent studies on the academic profession and work continue to be based on self-reported data (Walstad and Allgood 2005).

Explanatory variables

In the survey, the respondents were asked to indicate which of four career trajectories applies to their professional experience. The specification of these trajectories in the survey is based on the literature on academic inbreeding following key assumptions of this literature, namely that analytical relevance is focused on geographical mobility and that precise knowledge of the activities performed under that mobility are not essential as long as that mobility is related to scholarly activities (Berelson 1960; Caplow and McGee 1958). The analytical focus is on the contact with other knowledge environments that geographical mobility allows, and the potential scholarly benefits derived from that mobility (Hagstrom 1971). This relates to Acker's (2005) employment related mobility which refers to job changes from one university to other (applied to the categories inbreeding, silver-corded, non-inbred and adherents), and activity related mobility, i.e., leaving the university to participate in research projects or training elsewhere for a period of time (for the pure and mobile inbred categories). It is also aligned with the understanding of academic mobility as encompassing shorter or longer, more or less temporary moves that are part of individual career development (Williams et al. 2004). The career typology is thus, designed and based conceptually on the literature, and the category boundaries are delimited by a key analytical element: mobility across institutions, or lack of, during the academic career.[3]

Among four options available in the survey, two corresponded to a non-inbred categorization, one to silver-corded, and another to inbred.[4] Two non-inbred trajectories were asked and those respondents that marked the option stating that their career trajectory meant employment at another university than the one where they concluded their doctoral studies and have remained there for the whole of their careers corresponded to Dutton's "adherents" classification. The inbred category was later divided among pure-inbreds and mobile inbreds with the help of two questions: one asked if the faculty did research or took courses outside the university which granted the respondent the doctoral degree, and the other asked if the faculty had done a post-doctorate early in their career, and if so, if it took place at an university other than the one that conferred the doctoral degree to the respondent or not. If inbred respondents answered negatively to any of these questions, they would be considered as "pure-inbreds", otherwise—and if their stays outside their institution lasted three or more months—[5]they would be considered as "mobile-inbreds". In the data, each faculty

[3] Such categorization strategy has been recently followed by the European Commission to facilitate the identification of researcher's careers stages to foster recruitment and mobility among higher education, public and industry sectors in the European Research Area (see EC 2011).

[4] A space for an open question was inserted for the respondents to add comments, in case they thought that their career path did not correspond one way or the other to the existing four options. This option was rarely used, and when it was used, it meant confirming choices already made concerning one of the four proposed career options.

[5] The 3 month period of geographical mobility is adopted by international organizations such as the OECD, UNESCO and EUROSTAT as the minimum mobility period outside the institution (Auriol et al. 2010).

member corresponds to a single career category, coded as "1" while the other categories are coded as "0".

Inbred faculty as a whole corresponds to 58 % of the sample, suggesting that Portuguese higher education is a text-book case of phenomena linked to academic inbreeding. As Table 3 shows, of the inbred faculty group, 32 % are pure-inbred faculty while 26 % are mobile-inbred faculty. 6 % of the sample are silver-corded faculty. Of the 36 % non-inbreds, 22 % consist of adherent faculty, highlighting Portugal as a country with a rather immobile academic labor market.

Control variables

This analysis makes use of several variables identified in the scientific productivity literature as impacting the scientific production of academics. The control variables are age, gender, number of students taught, allocation of teaching effort, administrative load per week, R&D project funding, participation in collaborative research projects, and scientific career output (Shin 2011; Defazio et al. 2009; Leahey et al. 2008; Dietz and Bozeman 2005; Miller et al. 2005; Stephan and Ma 2005). The scientific career output variable, although based upon previous literature, does not represent the accumulated career output, but rather the career production divided by the number of career years. This allows controlling for age and career years, avoiding the usual high correlation between the two variables which constrains their simultaneous use. Scientific fields and institutions are also included in the regressions as fixed effects (see "Model" below). While scientific fields control for different specific disciplinary cultures and publishing patterns, institutional controls prevent the results from being biased due to unobserved heterogeneity associated to institutional effects.

Model

For the analysis, we will use two distinct regression models according to the characteristics of the dependent variables. While analyzing the effects of academic inbreeding upon research information exchange practices, we perform a linear regression as follows:

$$Y_{ijk} = x'_{ijk}\beta + \alpha_j + \delta_k + e_{ijk}$$

where Y_{ijk} is the information exchange practices for academic i at university j for scientific area k. The independent variables (x_{ijk}) include dummy variables for silver-corded, pure inbreds, mobile inbreds and adherents. The analyses always have the non-inbreds as the baseline. The other independent variables refer to the control variables previously mentioned, including fixed effects for institution (α_j) and scientific area (δ_k). In testing the behavior of the career paths of academics on scientific productivity, we use a regression that can handle a dependent variable that is non-negative and based on counts. Since overdispersion was found in the count models, we use a negative binomial regression based on $P(Y_{ijk} = y_{ijk}) = F(x'_{ijk}\beta + \alpha_j + \delta_k)$, where F is the negative binomial distribution, Y_{ijk} refers to the scientific output of academic i at institution j, and scientific field k, x_{ijk} represent the same independent variables described above, as well as the institutional and scientific field fixed effects (a_i are the institutional effects and δ_k are the scientific field effects). Also, due to the presence of heteroskedasticity, robust standard errors were computed for all models.

Results

The first analysis tests the assumption proposed in the literature that silver-corded faculty and inbred faculty have different characteristics and scientific productivity patterns. Table 4 (models 1–3) shows that inbreds supervise 15 % fewer doctoral theses than non-inbreds, as well as 11 % fewer articles in international journals, but out-produce non-inbreds in the production of articles in national journals by 23 %.[6] The scientific productivity of silver-corded faculty is undifferentiated from that produced by non-inbred academics, but they also out-produce the latter in the production of articles published in national journals by 40 %. These results support Berelson's (1960) distinction between inbreds and silver-corded academics and Caplow and McGee's (1958) argument that silver-corded faculty can be very competitive in academic labor markets, if the basis for the competition is based on scientific output performance. This is complemented by the fact that the number of doctoral theses supervised by silver-corded faculty and non-inbreds is indistinguishable, while the former contributes significantly more to the production of articles in national journals.

These results also confirm Birnbaum's (2005) and Shimbori's (1981) expectations that a scientific publication specialization would occur between inbreds and non-inbreds, with inbreds directing their scientific disclosure efforts towards national outlets, while non-inbreds are more internationally focused. Birnbaum (2005) predicted such patterns, justifying inbreds' orientation towards national-oriented journals as a result of their inability to publish in more competitive international journals. As Shimbori's (1981) noted, national refereed journals are frequently associated with small, national disciplinary and scientific associations, which tend to facilitate publication of its members in their outlets. Although contributions to national journals are relevant, and in some fields critical, in order to assure the maintenance of a national scientific culture or because most of the target audience is inherently national (e.g., studies in Czech literature), the publications that increasingly have greater impact, transferability, and visibility are the ones written in English and directed towards the international scientific arena (Kyvik 2003). A clear evidence of this attitude is the use of international publications in global university rankings (Deem et al. 2008).

In terms of research information exchange dynamics, the findings suggest that silver-corded academics favor internal over external information exchange concerning research issues and practices when compared with non-inbreds (models 7 and 8). In this regard, the communication behavior of silver-corded faculty is similar to the one of inbreds, in the sense that it is more focused within their own university, than with the outside of their own university, when compared with non-inbreds. However, the research related communication focus within the university where the silver-corded faculty is based is not as strong as it is for inbred faculty. At the same time this result is somewhat unsurprising since it is expected that silver-corded faculty have stronger linkages with the Alma Mater than non-inbred faculty, as several of these ties were established during the doctoral studies, a key socialization period in the academic career (Delamont and Atkinson 2001). Moreover, it is known that in higher education systems where high rates of inbreeding are pronounced, the linkages formed with the mentors during the PhD tend to be particularly strong, prevailing throughout the academic career (Horta et al. 2011).

[6] Tables report regression coefficients. Thus, any magnitudes reported are calculated after estimating marginal effects.

Table 4 Effect of academic inbreeding and silver-corded academics on scientific productivity (Negative Binomial Regression, models 1–6) and on information exchange practices (Linear Fixed Effects Regression, models 7 and 8), Robust Standard Errors

	PhD thesis (1)	Articles international journals (2)	Articles national journals (3)	PhD thesis (4)	Articles international journals (5)	Articles national journals (6)	External Research IE (7)	External Research IE (8)
Silver_corded	0.088	0.135	0.426**	0.089	0.146	0.424**	−0.461*	−0.455*
	(0.20)	(0.14)	(0.18)	(0.20)	(0.14)	(0.18)	(0.25)	(0.25)
Inbreds	−0.167**	−0.134*	0.301***				−0.680***	
	(0.083)	(0.069)	(0.11)				(0.11)	
Pure_inbreds				−0.188*	−0.267***	0.339***		−0.839***
				(0.097)	(0.092)	(0.12)		(0.12)
Mobile_inbreds				−0.146	−0.020	0.256**		−0.507***
				(0.098)	(0.074)	(0.13)		(0.13)
Age	0.028***	0.001	0.030***	0.028***	0.001	0.031***	0.01	0.009
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)
Female	−0.029	−0.164**	0.152	−0.029	−0.160**	0.153	−0.096	−0.096
	(0.084)	(0.065)	(0.094)	(0.084)	(0.066)	(0.094)	(0.099)	(0.099)
Funded research	0.285**	0.573***	−0.103	0.283**	0.578***	−0.102	0.129	0.124
	(0.11)	(0.094)	(0.12)	(0.11)	(0.092)	(0.12)	(0.12)	(0.12)
Participation R&D project	0.403**	0.458***	0.288	0.399**	0.417***	0.300	−0.203	−0.242
	(0.19)	(0.12)	(0.21)	(0.19)	(0.12)	(0.21)	(0.20)	(0.20)
Holds position other institution	0.108	−0.070	0.098	0.103	−0.097	0.106	0.255**	0.220*
	(0.098)	(0.083)	(0.12)	(0.097)	(0.085)	(0.12)	(0.11)	(0.11)
Administrative hours per week	0.008	−0.008	0.041***	0.008	−0.006	0.040***	−0.025*	−0.023*
	(0.012)	(0.010)	(0.015)	(0.012)	(0.010)	(0.015)	(0.013)	(0.013)
Teaches graduate stud. only	0.065	0.402***	0.158	0.063	0.399***	0.163	−0.125	−0.146
	(0.14)	(0.14)	(0.30)	(0.14)	(0.14)	(0.30)	(0.18)	(0.18)
Teaches undergrad stud only	−1.235***	−0.094	−0.383**	−1.233***	−0.087	−0.380**	−0.059	−0.0566
	(0.22)	(0.12)	(0.19)	(0.22)	(0.12)	(0.19)	(0.18)	(0.18)

Table 4 continued

	PhD thesis (1)	Articles international journals (2)	Articles national journals (3)	PhD thesis (4)	Articles international journals (5)	Articles national journals (6)	External Research IE (7)	External Research IE (8)
Total students taught	0.0002	0.0001	0.00001	0.0002	0.0001	0.00002	−0.0002	−0.0002
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Publications_career_year	0.024*	0.047***	0.080***	0.024*	0.045***	0.080***	−0.013	−0.014
	(0.014)	(0.012)	(0.022)	(0.014)	(0.012)	(0.022)	(0.010)	(0.010)
Natural sciences	−0.330**	1.411***	−1.070***	−0.336**	1.366***	−1.055***	−0.205	−0.261
	(0.15)	(0.15)	(0.15)	(0.15)	(0.16)	(0.15)	(0.17)	(0.18)
Engineering	−0.207	1.293***	−0.831***	−0.212	1.255***	−0.813***	−0.353*	−0.405**
	(0.16)	(0.17)	(0.15)	(0.16)	(0.17)	(0.15)	(0.19)	(0.20)
Health sciences	−0.081	1.680***	−0.026	−0.089	1.625***	−0.011	−0.378	−0.427
	(0.21)	(0.20)	(0.22)	(0.21)	(0.19)	(0.22)	(0.26)	(0.27)
Agricultural sciences	−0.264	1.169***	−0.389*	−0.273	1.116***	−0.372*	−0.663**	−0.732***
	(0.24)	(0.21)	(0.22)	(0.24)	(0.21)	(0.22)	(0.27)	(0.27)
Social sciences	−0.085	0.515***	−0.159	−0.084	0.512***	−0.159	0.047	0.046
	(0.15)	(0.17)	(0.13)	(0.15)	(0.17)	(0.13)	(0.18)	(0.18)
Constant	−1.398***	−0.531*	−1.301***	−1.385***	−0.471	−1.341***	−0.357	−0.259
	(0.37)	(0.31)	(0.41)	(0.37)	(0.31)	(0.41)	(0.47)	(0.47)
Observations	1,004	1,018	1,013	1,004	1,018	1,013	1,048	1,048
Log likelihood	−1626	−2,606	−1,904	−1,626	−2,602	−1,904	–	–
R-squared	–	–	–	–	–	–	0.10	0.11

The analysis of this table includes institutional controls (not shown in the table); * $p < 0.10$; ** $p < 0.05$; *** $p < 0.001$

The analysis also shows that there are differences among categories of inbreds, and that a reformulation of the concept of academic inbreeding based on mobility during and right after the doctoral degree, yet before the academic career starts is relevant. The analysis of scientific productivity of models 4–6 shows that pure inbreds (representing the extreme cases of immobility) supervise 16 % fewer doctoral theses, and produce 20 % fewer articles in international journals than non-inbreds, out-producing the latter only in the production of articles in national journals by 28 %. Unlike pure inbreds, mobile inbreds have an output in terms of articles published in international journals that is indistinguishable of that of non-inbreds, although they publish 21 % more articles in national scientific outlets than the latter. This suggests that the less mobile the academics are, the less they publish in international venues, but the greater is their national scientific output.

When the analysis is performed for academic information exchange behaviors, the results show that, when compared with non-inbreds, both mobile and pure inbreds prefer internal academic information networks to acquire and exchange knowledge on research related issues. However, the reliance on internal academic information networks is greater for the pure inbreds than it is for the mobile inbreds (model 8). This is expected, since mobility outside of the university during the doctoral and postdoctoral periods is expected to widen the academics' knowledge pool and facilitate the access to a broader set of knowledge sources (Horta 2009).

The next analysis compares the scientific productivity and information exchange behavior of adherent faculty with that of inbreds, having the mobile non-inbreds as the baseline (Table 5). The results concerning scientific productivity (models 9–14) show that the scientific profile of adherent academics is to a large extent different from the other non-inbred faculty (who changed jobs at least twice during their careers). The scientific productivity of adherent faculty is particularly similar to that of mobile-inbreds. Both adherent and mobile inbred faculty supervise fewer doctoral theses (adherents 21 % less; mobile inbreds 26 % less), and publish more articles in national journals (adherents 35 % more; mobile inbreds 46 % more) than mobile non-inbreds. The analysis of Figs. 1, 2 and 3, which predicts the scientific output of the various academic career paths, based on models 12–14, underlines the resemblance between the production output of adherent and mobile inbred faculty, in particular when concerning the number of supervised PhDs and articles published in internationally refereed journals.

When the scientific output of adherents is compared to that of silver-corded academics, another category of academics with limited mobility, the adherent academics scientific productivity tends to be lower. The latter supervise fewer doctoral theses, and do not produce as many articles in national journals (adherents 35 % more; silver-corded 75 % more) when compared with the baseline of mobile non-inbreds. Figures 1, 2 and 3 analysis reinforces this argument by showing that the most highly productive adherent faculty is only able to produce as many outputs as the least productive silver-corded faculty.

Adherent faculty also favors internal over external research information exchange as silver-corded faculty do. In fact, the academic information exchange behavior of adherent faculty is similar to those silver-corded faculty that are more oriented to exchange research related information outside the university (Fig. 4). Nonetheless, the adherent faculty reliance on internal university academic information exchange is never as extreme as it is for inbred faculty. On the other hand, the communication patterns of adherent faculty are clearly distinguishable than that of mobile non inbred faculty and much more oriented towards the university than to the outside. Overall, these results address Dutton's (1980)

Table 5 Effects of academic inbreeding, silver-corded and adherent academics on scientific productivity (Negative Binomial Regression, models 9—14) and on information exchange practices (Linear fixed Effects regression, models 15 and 16), Robust Standard Errors

	PhD thesis (9)	Articles international journals (10)	Articles national journals (11)	PhD thesis (12)	Articles international journals (13)	Articles national journals (14)	External Research IE (15)	External Research IE (16)
Silver_corded	−0.071	0.058	0.705***	−0.070	0.071	0.701***	−0.825***	−0.819***
	(0.21)	(0.15)	(0.23)	(0.21)	(0.15)	(0.23)	(0.27)	(0.27)
Inbreds	−0.326***	−0.212**	0.572***				−1.046***	
	(0.12)	(0.097)	(0.18)				(0.16)	
Pure_inbreds				−0.347***	−0.342***	0.605***		−1.203***
				(0.13)	(0.11)	(0.18)		(0.17)
Mobile_inbreds				−0.305**	−0.096	0.529***		−0.873***
				(0.13)	(0.099)	(0.19)		(0.17)
Adherents	−0.254*	−0.121	0.407**	−0.253*	−0.117	0.404**	−0.562***	−0.561***
	(0.13)	(0.10)	(0.19)	(0.13)	(0.10)	(0.19)	(0.17)	(0.17)
Age	0.028***	0.001	0.030***	0.028***	0.001	0.030***	0.010	0.009
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)
Female	−0.014	−0.156**	0.141	−0.014	−0.153**	0.141	−0.075	−0.075
	(0.084)	(0.066)	(0.095)	(0.084)	(0.066)	(0.095)	(0.099)	(0.099)
Funded research	0.280**	0.573***	−0.112	0.279**	0.578***	−0.111	0.132	0.127
	(0.11)	(0.094)	(0.13)	(0.11)	(0.092)	(0.13)	(0.12)	(0.12)
Participation R&D project	0.396**	0.452***	0.312	0.392**	0.411***	0.323	−0.237	−0.276
	(0.19)	(0.12)	(0.22)	(0.19)	(0.12)	(0.21)	(0.21)	(0.21)
Holds position other institution	0.112	−0.066	0.092	0.107	−0.093	0.099	0.259**	0.225**
	(0.098)	(0.083)	(0.12)	(0.097)	(0.085)	(0.12)	(0.11)	(0.11)
Administrative hours per week	0.009	−0.007	0.039***	0.009	−0.005	0.038***	−0.022*	−0.020
	(0.012)	(0.010)	(0.014)	(0.012)	(0.010)	(0.014)	(0.013)	(0.013)

Table 5 continued

	PhD thesis (9)	Articles international journals (10)	Articles national journals (11)	PhD thesis (12)	Articles international journals (13)	Articles national journals (14)	External Research IE (15)	External Research IE (16)
Teaches graduate stud. only	0.076	0.408***	0.109	0.074	0.404***	0.114	−0.129	−0.150
	(0.14)	(0.14)	(0.29)	(0.14)	(0.14)	(0.29)	(0.18)	(0.18)
Teaches undergrad stud only	−1.241***	−0.093	−0.382**	−1.239***	−0.086	−0.379**	−0.072	−0.070
	(0.23)	(0.12)	(0.19)	(0.23)	(0.12)	(0.19)	(0.18)	(0.18)
Total students taught	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	−0.0002	−0.0002
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Publications_career_year	0.025*	0.047***	0.080***	0.024*	0.045***	0.080***	−0.012	−0.013
	(0.014)	(0.012)	(0.023)	(0.014)	(0.012)	(0.023)	(0.010)	(0.010)
Natural sciences	−0.324**	1.417***	−1.101***	−0.329**	1.372***	−1.087***	−0.186	−0.242
	(0.15)	(0.15)	(0.15)	(0.15)	(0.16)	(0.15)	(0.17)	(0.18)
Engineering	−0.210	1.297***	−0.853***	−0.215	1.259***	−0.837***	−0.350*	−0.402**
	(0.16)	(0.17)	(0.15)	(0.16)	(0.17)	(0.15)	(0.19)	(0.19)
Health sciences	−0.082	1.681***	−0.054	−0.089	1.626***	−0.040	−0.369	−0.418
	(0.21)	(0.20)	(0.22)	(0.21)	(0.19)	(0.22)	(0.27)	(0.27)
Agricultural sciences	−0.250	1.181***	−0.410*	−0.259	1.128***	−0.395*	−0.627**	−0.696**
	(0.24)	(0.21)	(0.22)	(0.24)	(0.21)	(0.22)	(0.27)	(0.27)
Social sciences	−0.080	0.520***	−0.158	−0.079	0.516***	−0.157	0.070	0.0695
	(0.15)	(0.17)	(0.14)	(0.15)	(0.17)	(0.14)	(0.18)	(0.18)
Constant	−1.216***	−0.443	−1.551***	−1.203***	−0.385	−1.586***	0.054	0.151
	(0.38)	(0.33)	(0.44)	(0.38)	(0.33)	(0.44)	(0.48)	(0.48)
Observations	1,004	1,018	1,013	1,004	1,018	1,013	1,048	1,048
Log likelihood	−1,624	−2,605	−1,901	−1,624	−2,601	−1,901	–	–
R-squared	–	–	–	–	–	–	0.11	0.12

The analysis of this table includes institutional controls (not shown in the table); * $p < 0.10$; ** $p < 0.05$; *** $p < 0.001$

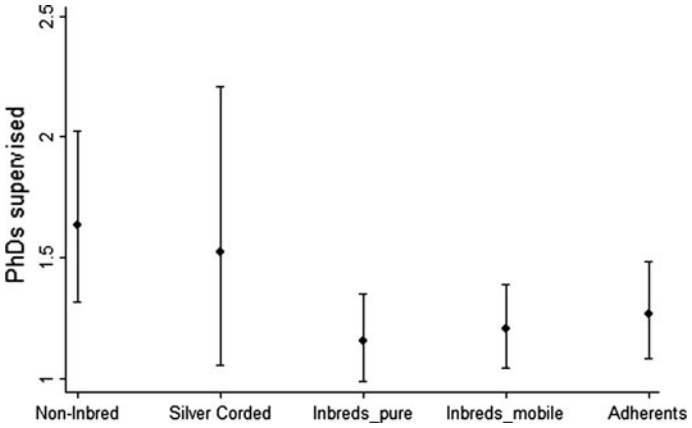

Fig. 1 Predicted number of PhDs supervised in the last 3 years for several academic career paths (with 95 % confidence intervals). *Note*: Non-inbred refers to mobile non inbreds (baseline)

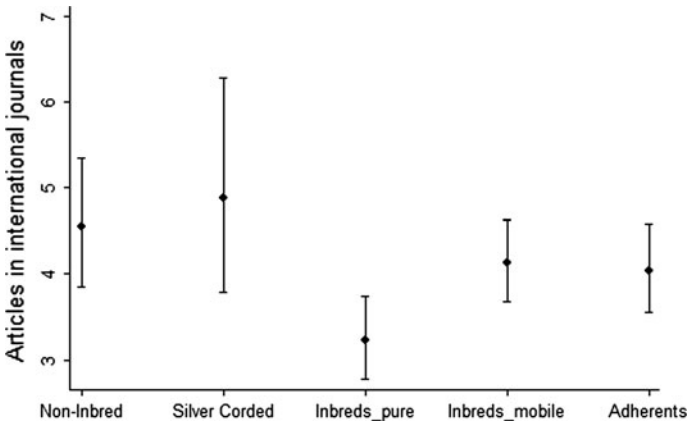

Fig. 2 Predicted number of articles published in international journals in the last 3 years for several academic career paths (with 95 % confidence intervals). *Note*: Non-inbred refers to mobile non inbreds (baseline)

concerns that the expected detrimental effects and behaviors of inbreeding could be observed in other academic and scientific paths—namely those paths entailing limited mobility—stressing the importance of mobility for academic communication and scientific productivity.

An interesting note concerning the analysis of Figs. 1, 2 and 3 is that they permit the visualization of scientific productivity specialization between inbred and non-inbred faculty in terms of scientific outputs as noted above. The figures show a pattern that indicates non-inbreds out-produce inbreds in the supervision of PhDs and the publication of articles in international journals, while inbreds publish more in national journals. At the same time, the figures also indicate that if pure inbreds are to a large extent indistinguishable from mobile inbreds, in terms of the publication of articles in national journals and in the supervision of PhDs, they have a clearly different publication pattern, in terms of publication of articles in international scientific journals (i.e.,

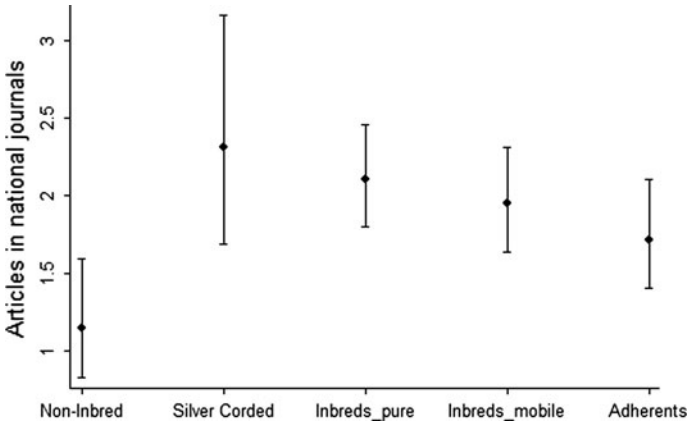

Fig. 3 Predicted number of articles published in national journals in the last 3 years for several academic career paths (with 95 % confidence intervals). *Note*: Non-inbred refers to mobile non inbreds (baseline)

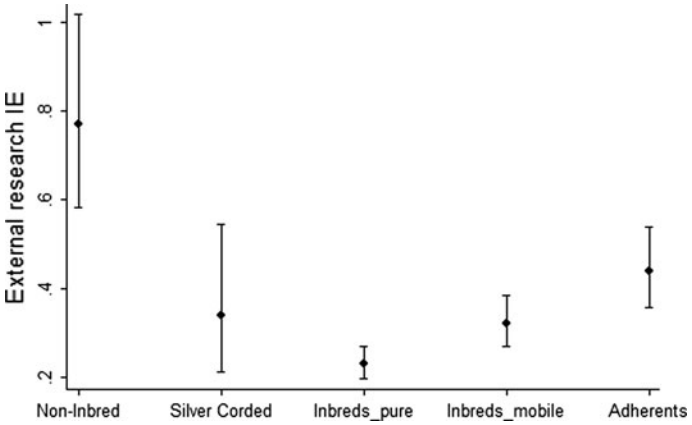

Fig. 4 Predicted information exchange dynamics for several academic career paths (with 95 % confidence intervals). *Note*: Non-inbred refers to mobile non inbreds (baseline)

they publish less in international journals). Mobile inbreds also have a distinguishable lesser reliance on internal knowledge sources to the university when compared to pure inbreds (Fig. 4).

Discussion

The results of the analyses confirm that geographic mobility is a key element in the creation of academic knowledge. Career mobility allows academics to participate in broader networks which pool not only diverse knowledge, but also information exchange beyond institutional boundaries (Dietz and Bozeman 2005). This permits access to a pool of knowledge unavailable to non-mobile scholars (Breschi and Catalini 2010). The results reinforce the literature that highlights the mobility of academics as beneficial for the creation and dissemination of knowledge (Evans 2010). However, the analysis of this study

also underlines the consequences of limited mobility and immobility of academics. It is found that, taken as a whole, immobile academics are the ones that concentrate their communication most within their universities. Immobile academics do not report a reliance on outside knowledge routinely used by mobile scholars. As well, by definition, non-mobile scholars cannot tap into nor utilize knowledge networks and sources, which—for all intents and purposes 'do not exist'. Their immobility confines them to work within internal information networks, and it is from these networks that they obtain knowledge (usually in a process of institutional knowledge reinforcement and legitimization).

Horta et al. (2010) suggested that this over-reliance on internal knowledge is responsible for their lower scientific output. In fact, this study's analysis shows the more immobile the academics are, the less they direct their production towards the international scientific community. In this regard, our findings confirm a publishing specialization, as predicted in the literature (Shimbori 1981; Birnbaum 2005), where inbreds (both pure and mobile) orient their production towards national journals, while non-inbreds use international journals as venues for their research. This suggests that, the less mobile academics', and in particular inbreds' method for maintaining a continuous publication rate is to publish in the less competitive outlets. The demand and scope of research required by national publications is not as stressed as it is in international publications, and because national publications are often edited by national disciplinary associations, it becomes potentially easier for the members of these associations to get their work published, even if a peer-review process exists. An example that the publications at national and international journals demand different requirements is that the research information exchange oriented towards outside the university impacts positively the production of articles in international journals, but does not impact the production in national journals.[7] In this sense, career mobility also impacts scientific productivity positively.

Beyond the issue of mobility this analysis' deep parsing of academic inbreeding supports the literature which stresses that academic inbreeding has detrimental effects on scientific productivity, and also encourages the closeness of the university through favoring internal academic information exchange over external academic information exchange (e.g., Pelz and Andrews 1966). However, this research shows that it is possible to diminish the academic inbreeding detrimental effects by creating opportunities and incentives for inbreds to be more mobile. The analysis indicates that, unlike pure inbreds, mobile inbreds tend to have scientific output trends that are closer to that of more mobile faculty. Moreover, these faculty types do not rely on internal research networks as much as pure inbreds do, indicating that mobility at the socialization stage (e.g., during the doctoral program and immediately following) is critical to diminish the expected negative effects of inbreeding on the academic endeavor. However, the communication behavior of mobile inbreds (and even silver-corded academics) shows that these academics tend to rely more on internal knowledge than those more mobile non-inbreds, and thus will not overly contribute to a greater openness of the university.

Yet the adherent academics, who in the great majority of the literature are expected to behave completely differently, in fact present information exchange and scientific productivity traits somewhat akin to those of mobile inbreds. This finding has implications for scientific and higher education systems characterized by low academic mobility levels and by a rather static academic labor force. Dutton's (1980) concerns that these faculty characteristics would not be too different from that expected from inbreds is confirmed and points towards potential detrimental effects of immobility at a systemic level.

[7] Analysis is not included in the article, but can be requested from the authors.

Conclusion

Through a deeper parsing of the concept of "inbred," this study contributes to the research on the effects of academic inbreeding on scientific production and research information exchange practices. The analysis reinforces recent research findings (i.e., academic inbreeding is detrimental to the production of scientific outputs; inbreds acquire research related information mainly within the university from which they graduated and which employs them), and contributes with new results concerning the relationship between academic inbreeding and mobility. This study offers three main findings:

1. The conceptual differentiation between silver-corded faculty and inbred faculty as proposed by Berelson (1960) is mostly supported since the scientific productivity of both academic groups is distinguishable, although with similarities on what concerns the publication of articles in national journals and also in terms of the information exchange dynamics.
2. A new re-definition of the concept of inbreeding is presented. This concept follows the same rationale that Berelson (1960) used to separate inbreds from non-inbreds (i.e., mobility), but implies an adjustment to contemporary academia and science. As such, pure inbreds,—those academics who have been immobile for the whole of their careers—may be the most extreme form of this phenomenon. If in terms of PhD supervised and articles published in national journals, the productivity of mobile and pure inbreds is identical, the same does not hold for the publication of articles in international journals since the mobile inbreds production of these outputs is comparatively greater. Moreover, mobile inbreds have research related communication behaviors closer to silver-corded or adherent academics, and as such should be considered as a distinct category in and of themselves.
3. Dutton's (1980) hypothesis stating that less mobile non-inbreds (adherents) would have characteristics relatively similar to inbreds is confirmed. Although the analysis indicates that adherent faculty scientific productivity is not similar to that of pure inbreds, their information exchange behavior is closer to that of mobile inbred faculty, thus making this type of academic still more centered on acquiring research related information exchange within the university than their mobile non-inbred peers. This finding suggests that incentives for academic mobility along the academic career are important to guarantee that academics have access to outside knowledge to the university where they are employed.

These findings provide valuable, important information for university managers and research institute leaders about each academic career path concerning research practices and scientific communication behaviors (including the insertion within international knowledge-based networks). This information is particularly useful for recruitment processes since the research potential and communication openness of each academic group is relatively expected based on the results of this study.

Unfortunately, the data did not allow an analysis in which the relationship between academic inbreeding and research quality could be made, a shortcoming to which future studies, both inside and outside of Portugal, should be attuned at systemic level. However, the split analysis between national and international publications, following the literature suggestions, already provides hints pointing towards a difference in research quality between inbreds and non-inbreds. This is also suggested by a very recent exploratory study performed at four technical universities in Turkey estimating that inbreds have a lesser scientific effectiveness when compared to non-inbreds (Inanc and Tuncer 2011). Another

issue that will be followed in future studies concerns the roles that inbreds can have on teaching and service, and thus perceive the impact that academic inbreeding has on these academic activities. Finally, in future studies, we expect to be able to analyze the scientific productivity across different career trajectories presented in this manuscript, using a longitudinal dataset to provide greater robustness to the findings.

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