Navel gazing: Academic inbreeding and scientific productivity

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Abstract

The practice of having PhDs employed by the university that trained them, commonly called "academic inbreeding," has long been assumed to have a damaging effect on scholarly practices and achievement. Despite this perception, existing work on academic inbreeding is scarce and mostly descriptive or exploratory. Using data from Mexico, we find evidence that, first, academic inbreeding is associated with lower scholarly output. Second, academically inbred faculty are more centered in their own institution and less open to the rest of the scientific world. This navel gazing is a critical driver of their inferior scientific output when compared with non-inbreds. Third, we reveal that academic inbreeding practices can result from institutional strategies by which inbreds have higher teaching loads and perform more outreach activities to free up time of non-inbreds to be dedicated to the research endeavor. Thus, a small presence of inbreds can benefit the output of non-inbreds and potentially the whole university; but a dominant inbred environment will stifle productivity, even for non inbreds. Overall, our analysis suggests that administrators and policy makers in developing nations aiming to develop a thriving research environment in universities should consider mechanisms to limit this practice.

1. Introduction

At the beginning of the 20th century, it was common to find major US land grant universities (McNeely, 1932) and Ivy League institutions (Handschin, 1910) where a large proportion of the faculty would stay as professors after completing their PhD. This practice of hiring your own, commonly called "academic inbreeding," has long been assumed to have a damaging effect on scholarly practices and

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achievement (Berelson, 1960; Pelz and Andrews, 1966). In 1908, when 64% of Harvard faculty were own graduates, president Charles W. Eliot warned that inbreeding presented “grave dangers for a university” (1908: 90). Historical studies suggest that, even then, inbred faculty had lesser recognition, both academic and economic, as well as lower levels of achievement and promotion when compared to non-inbreds (Eells and Cleveland, 1999; Reeves et al., 1933).

Academic inbreeding continues today in some US schools (Burris, 2004). For example, the proportion of inbred entry-level faculty at the Harvard Law School is 81% and at the Yale Law School 73% (Eisenberg and Wells, 2000). Yet, as the US academic system evolved, the overall levels of inbreeding declined to less than 20% and often below 10%. A similar situation happened in the United Kingdom (Navarro and Rivero, 2001). In contrast with these two nations, inbreeding is seen in many countries as “business as usual,” especially those with emergent scientific systems. Estimates suggest that academic inbreeding in Spain is as high as 95% (Navarro, A. Rivero, 2001); in Portugal it is 80% (Heitor and Horta, 2004). High rates have also been reported at French (Navarro and Rivero, 2001), Swedish (Bleiklie and Hostaker, 2004), Russian (Smolentseva, 2003), Mexican (Santibañez et al., 2005), Korean (Johnsrud, 1993), Chinese (Yimin and Lei, 2003) and Japanese national universities (Yamanoi, 2005).

The existence of severe inbreeding environments in a variety of countries now aiming to become leading centers of scholarly research has been raising critical questions as to what the real impact of this practice on universities is (Navarro and Rivero, 2001; Soler, 2001; EUA, 2004). This has been recognized in the European Commission “white paper on education and learning” (European Commission, 1995), which identified academic inbreeding as a worrisome problem for European research. Yet, because of its decline in importance within leading research nations, the interest in academic inbreeding from a research perspective waned. As a result, analyses of this issue have been either exploratory or a marginal item in the context of a broader study (Soler 2001, Wyer and Conrad 1984, Hargens and Farr’s 1973, McGee 1960). Studies have typically few controls for possible confounds affecting relevant outcomes, in particular research productivity. Moreover, it is not clear whether outcomes gaps result from the inbreeding condition, or rather result from intrinsic differences between inbreds and non-inbreds.

A proper understanding of the impact of academic inbreeding is clearly of direct interest to university administrators and policy makers in the area of science, technology and higher education. But the relevance is more far reaching. The university research function in particular is of direct relevance for local industry innovation (e.g.: Henderson et al., 1998). University research effort has been found, for example, to have an impact on local patenting rates (Jaffe, 1989; Acs et al., 1992). It has also been shown that the strongest firms in several high tech sectors depend strongly on academic research and academic-based researchers (Furman and MacGarvie, 2007; Nelson, 1993; Spencer, 2001; Zucker et al. 2006). Thus, a potentially negative impact of academic inbreeding in university research output and quality will play a critical limiting role on the scientific and economic outcomes of a nation.

Studying the impact of academic inbreeding in scholarly practices is also relevant to further our understanding of the role of individual mobility in the processes of knowledge generation in research environments. A budding literature on this topic suggests that hiring external researchers into existing environments is important for the ability of organizations to generate and access new knowledge. For example, Song et al. (2003) show that researcher mobility is more likely to result in inter-firm knowledge transfer while Lacetera et al (2004) demonstrate that hiring star scientists can reshape the direction of research organizations. Looking at academic inbreeding helps to reflect on what happens to practices and outcomes of scientists that never change their research environment, as compared to those that are mobile.

This paper assesses the impact of academic inbreeding on scholarly practices and achievement using a unique dataset on Mexican scientists, their characteristics, behaviors and outputs. Mexico's scientific system is particularly suitable to study the effects of academic inbreeding because its size, diversity and level of development make it a reasonable representative of many other emerging nations around the world (Veloso *et al.,* 2006).

This article makes several contributions. We start by developing an empirical setting that clearly shows that inbred researchers have indeed lower research output than their non-inbred counterparts. This confirms prior assertions on the negative impacts of inbreeding. Then, we advance our understanding of the inbreeding phenomenon in several new directions. First, we demonstrate that the negative impact of inbreeding on scientific achievement can be explained by the parochialism of inbred faculty, which are much less likely than their non-inbred colleagues to exchange information outside their university. Then, we address directly the institutional dimension, studying the rationale for and ultimate danger associated with the recruitment of inbred faculty. In fact, while inbreds may have lower scientific productivity, our results show they can fulfill other universities missions, in particular teaching and linkages to the business environment. Morover, the findings suggest that that retaining some inbreds may be sensible because they can free up the time of non inbreds to concentrate on research and thus contribute to their productivity. Yet, the analysis alo shows that, as the presence of inbreds becomes dominant, their culture will ultimately affect non-inbreds, which experience a reduction in their research output.

The paper is organized as follows. The next section reviews the critical literature and presents the key hypothesis to be tested. Section 3 describes the data and empirical models to be used. Section 4 presents the results, section 5 discusses the findings and section 6 concludes.

2. Literature and Hypotheses

2.1. Previous studies of academic inbreeding

The initial studies that discuss inbreeding appear in the context of institutional characterizations of universities in the United States (e.g.: Reeves et al., 1933 study of the University of Chicago; Hollingshead, 1938 study of Indiana University; McNeely, 1932 study of land grant universities). They typically present descriptive statistics on the universities and their faculty, including academic inbreeding. These studies note that inbred faculty typically displayed lower levels of achievement when compared to non-inbred faculty, but do not attempt to estimate such effects. Then, in 1966, Pelz and Andrews publish their important sociological study of scientists, where they suggest two fundamental notions associated with the potential negative impact of academic inbreeding. First, they stated that a critical issue with inbreeding rests on the idea that inbred faculty are less creative, independent, connected and original than non-inbred faculty. Second, as a result of the first notion, they suggest that inbred academics will be less productive and have a lower scientific impact. Again, they do not empirically estimate these two notions.

The limited literature addressing academic inbreeding since the sixties has typically focused on analyzing its impact on scientific productivity and has overlooked the first notion proposed by Pelz and Andrews (1966). Only one qualitative study of Brazilian agricultural scientists, by Velho and Krige (1984), reports that academically inbred scientists were more likely to display low levels of communication with other scientists, as well as a preference to interact with colleagues at the institution rather than with colleagues from other universities and R&D units. They do not try to calculate effects.

The first empirical analysis focusing on the relationship between academic inbreeding and scientific productivity was performed by McGee (1960). While he concluded that inbred faculty were more productive than non-inbreds, his work lacked controls for confounding factors, which limited the validity of his conclusions (see the critique by Lieberson and Gold, 1961). Similarly, subsequent research by Hargens and Farr (1973) also argues that inbred faculty generate less scientific outputs than non-inbred faculty. Yet, their empirical approach was a set of simple correlations, again with obvious limitations. More recently, Wyer and Conrad (1984) use the 1977 survey of the American Professoriate, which encompasses 160 institutions from all major academic disciplines, to examine the relationship between institutional origins and scientific productivity; one of the dimensions they cover is inbreeding. Contrary to previous studies, they find that the research productivity of inbred and non-inbred faculty was very similar. An important difference to prior work was an attempt to control for the effects of research vs. teaching time allocation by dividing the rate of publications per career year by the amount of time reported by each faculty member on research and teaching activities. But the study offered limited progress methodologically over previous work in terms of the models used in the estimation because it does not include any individual or institutional controls. Even the most recent work on the topic continues to be exploratory. The analysis of Soler (2001), where the productivity of 51 ecology and zoology departments in Europe is correlated with their levels of academic inbreeding does not differ substantially from the 1970s analysis on academic inbreeding performed by Hargen and Farr.

In sum, typical studies on academic inbreeding rely mostly on descriptive statistics. Many of them only point out to large inbreeding rates without performing any meaningful analysis. Other studies use simple univariate methods to assess the effects of academic inbreeding on scholarly achievement. As a result, all lack critical controls that could explain any observed differences in achievement between inbreds and non inbreds such that they would not be due to their inbred status. For example, in a system where inbreeding might be a recent phenomenon, inbreds may publish less because they are more junior and not because they stayed in the same school where they got the PhD. Thus, an analysis that does not control for seniority could wrongly attribute a gap in productivity to inbreeding, when it could in fact result from differences in experience. Prior estimations have also neglected to address two other fundamental issues. The first is why inbreds are less productive than their counterparts that come from another university. The second is to go beyond the individual and also try to understand the broader role of inbreeding in the institution. The obvious question one might ask is why would universities hire inbreds if the established perception is that they are less productive researchers? This work addresses these issues and their links directly.

2.2. Hypotheses

Pelz and Andrews (1966) advanced the untested notion that inbred faculty are less creative, independent, connected and original than non-inbred faculty. They argued in particular that inbreeding is associated with a scholarly information exchange practice that favors internal sources over external contacts with other institutions. This behavior implies that, at individual level, inbred faculty members carry their academic and scholarly activities under a framework of extreme dependence on internal networks and on pre-established relationships. These relationships are often dependent on a strong professional and social connection with the inbred faculty member’s former doctoral supervisors. When a graduate stays in the university his or her activities become so embedded in the organizational culture and *modus operandi* that he or she may not feel the need to look for information elsewhere (Pelz and Andrews, 1966). Thus, the first hypothesis is:

> *H1 - Openness hypothesis: “Non-inbred faculty members are more likely to exchange scholarly related information outside the university than inbred faculty members”*

The second critical notion of the literature, also well articulated by Pelz and Andrews (1966), is that academically inbred faculty members will produce less scientific output when compared to non-inbred faculty members. The generation of new knowledge in a university relies extensively on the creativity of individual researchers. However, the stimulation of individual creativity requires ever more frequently the combination of a pool of existing and emergent knowledge, with most of the latter existing outside the organization (See Kogut and Zander, 1992; Fleming and Sorenson, 2004). Openness and external links take time and effort to build (Levin and Cross, 2004), but are particularly important in the current research environment (Adams et al. 2005). They are the critical vehicle by which academics effectively integrate the 'invisible colleges' (Crane, 1972) which inform them of where and how to learn and accumulate relevant knowledge from (Nelson and Winter, 1982; Cohen and Levinthal, 1990), and understand the rules of the game at (North, 1990).

If an academic maintains a reduced connectedness with the exterior of the university where he or she is based, it is probable that his or her awareness of critical events, challenges, opportunities and changes at system level will be limited. But above all, as argued by Pelz and Andrew (1966), the individual inbred academic faculty members is less connected with the exterior, then he or she will have difficulties in renewing his or hers knowledge base. Since knowledge depreciates (Argote, 1999), it is reasonable to argue that with time inbred faculty members will possess an increasingly outdated knowledge. This is deemed to be reflected in their scholarly achievements.

The importance of these external links has been noted in prior studies that stress the importance of hiring external researchers to open the organization to new knowledge (Song et al., 2003; Lecetera et al., 2004). This is seen as a way to balance the typical path dependent and localized search processes that individual researchers undertake in knowledge intensive environments (Nelson and Winter, 1982; Stuart and Poldony, 1996; Rosenkopf and Nerkar, 2001; Singh, 2005). This leads to the second hypothesis:

H2a - Productivity hypothesis:"Inbred faculty members produce fewer scientific outputs than non-inbred faculty members"

Yet, the discussion above suggests that it is critical for our understanding of this phenomenon to go beyond the notion that inbreeding affects scientific productivity and to directly assess the role that openness plays as the link between inbreeding and productivity at individual level:

H2b – Openness-productivity hypothesis: "inbred faculty members produce fewer scientific outputs because they are less open to exterior information flows than non-inbred faculty members"

Despite the severe deficit of confirmatory empirical evidence, inbreeding has long been seen by most literature and institutions as having negative consequences (see for example the "white paper on education and learning", European Commission, 1995). Thus, a critical question is why would universities hire inbreds if the expectation is that they will have an inferior scientific performance? This issue has been sidelined by previous work.

The important presence of inbred faculty in academic systems around the world suggests that there may be particular motives for universities to hire their own graduates. One perspective could be that academic inbreeding is a phase of development in higher education systems. The evolution of the US system could lend some support to this notion. Another observation consistent with this idea is the fact that the higher rates of academic inbreeding are typically found in leading national research universities, those where the first doctoral programs in a country were created (Horta, 2008; Heitor and Horta, 2004). However, inbreeding rates are currently high in many systems that are now beyond their initial stages of development and in universities created more recently. This suggests that the stage of development may not be a sufficient explanation for the practice. Thus inbreds are probably playing particular roles or bringing some certain benefits for higher education institutions.

The reasoning that academic inbreeding can be part of an institutional strategy becomes more apparent if one reflects on how a university might benefit from the characteristics of its recent doctorates. These were socialized in the organizational routines of the university where they studied, are aware of its culture, and most likely know well the curricula and lecturing style performed there. Thus, they can easily start teaching and effortlessly enter the institutional setting. Moreover, they are available for employment with lesser effort and with some quality assurance *vis* a *vis* unknown external applicants. For the recent doctorates this is a best case scenario because they obtain an academic position right after graduation in an environment they know. From this perspective, it appears to be is a win-win situation for both the university and its doctorates.

If academic inbreeding is used as an institutional strategy, it should be reflected in the practices of the organization, which would treat inbreds and non-inbreds differently. This possibility has been noted in prior studies. For example, an early report prepared for the US Office of Education (McNeely, 1932) found slightly lower salaries for inbred faculty when compared to non-inbred faculty. This perspective was later reinforced by McGee's (1960) study of the University of Texas. According to him, the university positively discriminated non-inbred faculty in their salaries so that it could be competitive in national higher education labor markets and attract faculty with higher scholar (and especially research) potential. Consistent with the notion that the university was doing this as a strategy, he also noted that inbred faculty have a higher teaching load than non-inbred faculty.

Nowadays, it is the research mission that gives the prestige to higher education institutions, but critical teaching, and increasingly "outreach" or "service" components, still need to be fulfilled on a continuous basis to generate resources and assure the broader role of the university in the national innovation system (see Cummings, 1998). Thus, it is reasonable to expect that higher education institutions will allocate easily available faculty, their own graduates, to teaching and "outreach" activities, while having non inbred faculty members preferably performing research, the activity where they can excel. Thus, we can advance a third hypothesis:

> *H3 – Inbreeding hiring hypothesis: "inbred faculty are hired under a resource management strategy to perform mainly non-research related activities"*

If the presence of inbred faculty allows non inbreds to concentrate more of their effort in research activities, where they are more productive, we should be able to see this effect in the research output. Thus, we may find that a small presence of inbreds to have a positive impact in the research output of the rest of the faculty. This could be a reason for universities to hire some of their own graduates. But there should be a limit to this benefit. First, since inbreds are expected to have lower productivity, as their presence grows in a university, their own output gap will eliminate any potential benefit they may bring to non-inbreds. Yet, we should expect a growing presence of inbreds to also affect non-inbreds.

As the presence of its own graduates grows in a university, it will be fostering the reproduction of locally learned knowledge and practices, as well as a consolidation of social structures in the organization (Frans *et al.*, 1999). This socialization process is expected to increasingly constrain the scope and flexibility of the organization (Camerer and Vepsalainen, 1988). If the dominant practices give less importance to the demands of a complex and fast evolving external knowledge (Nowotny et al., 2001), these might impede the renewal of the academics' pool of knowledge in the whole university. This means that the effects will not restrain themselves to the individual but rather to the organization as a whole. This should ultimately be reflected in the output and quality of the research work of all researchers in the organization, including the non-inbreds. In this context, we will consider that there will be an inverted U relation between the presence of academic inbreeding and the productivity on non-inbreds:

> *H4 – Organizational productivity hypothesis: "low rates of academic inbreeding will have a positive impact in the productivity of non-inbreds, but high academic inbreeding rates will affect negatively their scientific productivity"*

3. Methods and data

3.1 Data Source and Characteristics

The dataset used in this study was generated through a survey conducted to analyze the impact of public policies in processes of institutional change within Mexican higher education institutions. As noted before, Mexico's scientific system is particularly suitable to study academic inbreeding because its size, diversity and level of development are comparable to a variety of other emerging nations around the world (Veloso *et al.,* 2006). Yet, it is important to note that the origin of the data may also limit our ability to extrapolate results to more mature environment such as the US or the UK, which may have developed alternative mechanisms to deal with potential pernicious effects of inbreeding.

The questionnaire, sponsored by CONACYT, the Mexican Science and Technology Foundation and directed by one of the authors, focused on the academic profession for the period between 1999 and 2002. The original dataset was determined based on the population of Mexican faculty members as reported by the institutions themselves to the *Asociación Nacional de Universidades e Instituciones de Educación Superior* (ANUIES). As a result of sampling calculations, 5,000 questionnaires were sent to faculty members of 82 higher education institutions. Of these, 3,861 were returned, representing a response rate of 79%. Respondents encompass 64 higher education institutions and all scientific fields[4].

Given the purpose of our analysis, this dataset was filtered using two requirements. The first was to include only faculty holding a PhD, because the PhD "alma mater" is how we distinguish inbreds from non-inbreds. The second was to consider only higher education institutions that granted doctoral degrees, because if an institution doesn't grant a PhD, all faculty in that school would be necessarily non-inbred. After the filtering process, the data includes 414 academics in 14 higher education institutions.

In our analysis, an academic is considered inbred when he or she was first hired and developed the career in the very same higher education institution where his or her doctoral degree was obtained (Berelson, 1960). In our data we characterized an academic as an inbred if the institution where the PhD was obtained was the same as the institution in which the academic career started, and was also where the academic is currently based. This minimizes the possibility of mistakenly categorizing as inbred faculty those holding a PhD from the same institution where they currently work but that have previously held a position in another school[5]. These are referred to in the literature as "silver corded" (Berelson, 1960). This distinction is important because empirical studies indicate that silver-corded academics tend to be scholarly superior and very competitive in the academic labor market (Caplow and McGee, 1958; Calhoun *et al.*, 1990). Given this characterization, academically inbred faculty represent 26% of our sample, with strong variation across institutions and areas of knowledge.

[4] For further information on the sampling methodology see Kuri et al. (2004)

[5] Researcher mobility in Mexico is very small. Therefore it is highly unlikely to have cases that start as inbred faculty, then leave to another school and finally return to their alma mater.

3.2. Data: information about variables

The analysis uses four types of variables: 1) a variable for information exchange, 2) scholarly output variables, 3) allocation of effort variables and 4) demographic variables. The categories and descriptive statistics for these variables are shown on Table 1.

Table 1 – Descriptive Statistics for all the variable categories

	Obs	Mean	Std.Dev.	Min	Max
INFORMATION EXCHANGE					
Information exchange practices – external openness score	398	-1.11	1.64	-5	5
SCHOLARLY OUTPUTS					
Number of undergraduate thesis supervised	409	1.99	2.17	0	9
Number of master thesis supervised	409	1.41	1.54	0	6
Number of PhD thesis supervised	409	0.65	1.05	0	4
Number of articles in peer reviews journals	409	2.82	2.28	0	9
Prototypes and patents	409	0.12	0.52	0	6
Number of consulting contracts (Government or private)	409	0.28	0.93	0	7
ALLOCATION OF EFFORT					
Conduct/participate collective R&D project	413	0.77	0.42	0	1
Had funding to develop R&D in the last 3 years	369	0.80	0.40	0	1
Teaches graduate students only	414	0.05	0.22	0	1
Teaches undergraduate students only	414	0.24	0.42	0	1
Average number of students per class	409	23.17	12.53	0	60
DEMOGRAPHIC					
Years since first job in academia	414	20.51	9.86	1	48
Male	414	0.63	0.48	0	1
Inbreeding	414	0.26	0.44	0	1
Inbreeding per scientific area and institution	414	0.26	0.21	0	1

Note: All the values refer to totals for years 1999-2002.

The first variable is a *measure of information exchange practices* or, more synthetically, an *external openness score*. It represents the degree to which an academic has a preference to exchange information inside its institution, which is reflected in a more negative score, or outside it, signaled through a larger positive score. This variable is constructed from several questions on information exchange included in the questionnaire. Faculty were asked to report on their information exchange practices in six categories: information exchange about research and teaching activities, information exchange about innovative subjects and articles, information exchange about equipment and research techniques, information exchange about financial sources for research, information exchange about publishing and diffusion of research results, and information exchange about job vacancies. For each category, the survey asked the academic what was his or her level of intensity in information exchange for two internal locations and two external locations. The two internal locations were the research group to which the academic belonged and other academics within the university. The two external locations were academics and institutions from other national institutions and academics and institutions from institutions outside the Mexican science and higher education system. Each answer had four possible levels: never, rarely, sometimes and frequently, which we coded from 1 to 4.

To assess if faculty favored information exchange inside or outside the university where they currently work, we created a scale based on the sum of two external minus the sum of the two internal questions, ranging from 6 (maximum external information exchange) to -6 (maximum internal information exchange). For example, an academic that frequently exchange information within its own research group (score of -4) and within the university (-4), but that rarely exchanges information with national peers (2) and never contacts outside the country (1) would obtain a score of -5, while an academic that frequently exchanges information with colleagues outside the university, both nationally (4) and internationally (4), and also frequently exchanges information with colleagues from his or her research group (-4) and sometimes within the broader institution (-3) would have a score of 1. This resulted in six scores of information exchange, one for each of the categories considered in the questionnaires. The variable used in our estimation, *external openness score,* is the average of the six scores. As it can be seen in Table 1, on average faculty prefer to exchange information inside their school, which is not surprising. Nevertheless, there is a wide variation across individuals.

The scholarly output variables considered in our analysis include the major functions associated with the mission of the university – education, research and outreach. The data for these variables is obtained directly from the questionnaire that asks each academic his or her output along each of the relevant dimensions between 1999 and 2002. The output variables associated with education are the number of thesis at undergraduate, master and PhD level supervised by the faculty (although at PhD level the output represents to a certain extent a mix between teaching and research). Research output is assessed using the number of articles in scientific peer reviewed journals[6]. To characterize outreach work we use the number of consulting contracts and as well as the numbers of prototypes and patents. We believe these two variables can cover a very broad range of outreach activities. These include dispensing advice to firms and the government, typical in social sciences and likely to be labeled as consultancy projects. But they also cover technical contracts, often present in the physical sciences and engineering, which may not be seen as consultancy, but are likely to entail developing physical prototypes for a client.

Another set of variables that are critical for the analysis refer to the allocation of effort by academics. Besides accounting for the academics' willingness or ability to perform particular activities, these variables also provide an indication on the task assignments of the academics in their institutions. The first variable of this group is participation in collective R&D projects, which is an indication of the degree of engagement of the faculty in scientific networks dealing with research. Most faculty members (77%) participate in these types of projects. We also verify whether the faculty member received funding in the previous three years to support R&D projects (80% have received). This will inform on the availability of resources that support the generation of research outputs[7].

We also have information on teaching activities. These include: whether or not the academic is teaching to undergraduates only (24%), teaching to graduates only (5%) or teaching to both undergraduate and graduate programs (the baseline), as well as the average number of students per class (23.2). These variables reflect the amount and type of teaching effort that the faculty is subject to. Previous analyses of institutional inbreeding highlight the importance of considering these activities when studying the effects of inbreeding in scientific outputs (e.g.:McGee's, 1960; Wyer and Conrad, 1984).

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[6] This measure of output is an established metric typically used in studies of scientific productivity (e.g. Levin and Stephan, 1991; Adams et al. 2005; Gonzalez-Brambila and Veloso, 2007). However, it also has limitations. First, journals may vary in quality. Thus, while controlling for journal quality would be a good refinement of our analysis, such data were not available for this research. Second, we are not covering other scholarly outputs of research, such as books and conference papers. Yet, these tend to be less consistent in nature and quality than peer reviewed journals and thus even more noisy measures of output than the one we are considering (Lewison, 2001).

[7] Because the system is overwhelmingly dominated by public universities, salary practices are such that there are no significant pay differences across faculty for the same academic rank.

The fourth category is key demographics. The first variable is years since first job in academia, which can control for the experience of the faculty[8]. The average experience of the faculty in the sample is 20 years. The second variable is gender, which has typically explained some difference in research productivity (Gonzalez-Brambila and Veloso, 2007).

Finally we have the inbreeding variable. In addition to the individual level of inbreeding, we constructed a variable that refers to the ratio of inbred faculty per scientific area and higher education institution. Universities can have different inbreeding rates between themselves as well as within them and across disciplinary fields.

4. Analysis and Results

The first hypothesis suggests that non-inbreds are more likely to exchange scholarly related information outside the university than inbreds. To test this hypothesis, we use the following regression:

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

where Y_{ijk} is the information exchange practices score for individual *i* in university *j* for scientific area *k*. The independent variables (x_{ijk}) include a dummy signaling academic inbreeding (zero for non-inbreds and one for inbreds), as well the demographics (e.g: male) and effort allocation variables (e.g.: average number of students per class), the typical controls for this literature (Gonzalez-Brambila and Veloso, 2007). In addition, as the equation above reveals, we will include fixed effects for institution (α_j) and scientific area (δ_k). These are relevant controls because different institutions and areas of knowledge will be associated with important heterogeneity in scientific performance and information exchange practices for both inbred and non-inbreds[9]. In deciding the areas, we followed the differentiation proposed by

[8] Experience in academia is sometimes considered with a linear as well as a squared term because faculty productivity is seen as first increasing, but then declining with age (Gonzalez-Brambila and Veloso, 2007; Levin and Stephan, 1991). We considered this variant across our estimations. Yet, the squared term was mostly non significant and its inclusion did not alter the rest of the results regression results. Thus, we decided to drop the quadratic term from the analysis and include only the linear term.

[9] For example, it is likely that the Universidad Nacional Autónoma de Mexico (UNAM), a large and well known institution, attracts better people for its ranks, both inbreds and non-inbreds, when compared to a small regional school. If this were the case, pooling the faculty from both schools in an analysis would lead to results that would be mostly driven by the differences between

ANUIES, the national association of higher education institutions in Mexico. The scientific fields considered in the estimation include natural sciences (what is named in Mexico as "exact sciences": mathematics, chemistry and physics), social and administration sciences, education and humanities, engineering and technology, health sciences and agrarian sciences. These institution and area effects will be included in all regressions but the will not reported in the tables due to space limitations.

Table 2 presents the results of the estimation. Given that greater values for the information exchange practices score represent more external openness, the findings provide a strong confirmation of the argument that inbred faculty collaborate and exchange less information outside their institutions and, as a result, are less likely to be integrated into national and international scholarly networks. The difference between individual inbred faculty members and individual non-inbred faculty members is significant, with inbreds having roughly 50% lower propensity to exchange external information when compared to non-inbreds. This result lends strong support the validity of the openness hypothesis.

Table 2 – Effect of academic inbreeding on information exchange practices; Linear Fixed Effects Regression, Robust Errors[10]

Variable	External openness score
Inbreeding	-0.548*** (0.200)
Years since first contract	0.008 (0.009)
Male	0.047 (0.187)
Participate collective R&D project	-0.011 (0.224)
Funding for R&D last 3 years	0.097 (0.225)
Teaches undergraduate students only	-0.492** (0.199)
Teaches graduate students only	0.649 (0.563)
Average number of students per class	-0.011 (0.007)
F (25, 328)	2.75***
R-Squared	0.15
Observations	354

*Note: * p<0.1; ** p<0.05; *** p<0.01*

institutions, in particular quality, size and proportions of inbred and non-inbred faculty in each school. Instead, what we are interested is in comparing the output of inbreds and non-inbreds within the same institution and field.

[10] We also performed this estimation using each individual information exchange practice, rather than the average value of the scores, using a a multivariate ordered logit regression model (see Wooldridge, 2001). The results and magnitudes of the effects were always consistent with the linear model presented in Table 2.

Next we analyze hypothesis 2, which suggests that inbreds produce fewer scientific outputs than non-inbreds. Estimating the impact of inbreeding on academic output requires a procedure that can handle a dependent variable that is non-negative and based on counts. Since our error term is over dispersed, we use a negative binomial regression based on $P(Y_{ijk} = y_{ijk}) = F(x_{ijk}'\beta + \alpha_j + \delta_k)$, where *F* is negative binomial distribution (see Wooldridge, 2001), Y_{ijk} is the scientific output of academic *i* in institution *j* and scientific field *k*, x_{ijk} are the same independent variables used in the empirical testing of hypothesis 1; likewise, a_i are the institutional effects and δ_k are the scientific field effects.

Table 3 – Effect of inbreeding on academic outputs; Negative Binomial Fixed Effects Regression, Robust Errors

	Supervision of undergrad thesis (1)	Supervision of master thesis (2)	Supervision of PhD Thesis (3)	Articles in peer review journals (4)	Consultancy (gov. or firms) (5)	Prototypes and patents (6)
Inbreeding	**-0.010 (0.058)**	**-0.063 (0.096)**	**0.088 (0.12)**	**-0.152** (0.069)**	**1.009*** (0.32)**	**0.536*** (0.11)**
Years since first contract	0.003 (0.005)	0.019*** (0.004)	0.022*** (0.008)	-0.012*** (0.004)	0.052*** (0.011)	0.039** (0.017)
Male	0.005 (0.081)	0.318*** (0.083)	0.170 (0.13)	0.155*** (0.043)	0.847* (0.47)	1.302*** (0.42)
Participate collective R&D project	0.131 (0.16)	0.420 (0.29)	0.738*** (0.14)	0.265*** (0.085)	0.612* (0.36)	-0.016 (0.24)
Funding for R&D last 3 years	0.066 (0.20)	0.057 (0.14)	0.585** (0.25)	0.239*** (0.081)	-0.370 (0.30)	0.888** (0.43)
Teaches undergraduate students only	-0.122 (0.20)	-0.738*** (0.11)	-0.940*** (0.26)	-0.265*** (0.097)	0.462 (0.41)	-0.003 (0.29)
Teaches graduate students only	-0.043 (0.33)	0.471* (0.21)	-0.230 (0.66)	-0.132 (0.22)	0.516 (0.66)	-0.284 (0.95)
Average number of students per class	0.009 (0.008)	-0.004 (0.004)	-0.013*** (0.005)	0.001 (0.001)	0.007 (0.01)	-0.020 (0.013)
Constant	0.201 (0.47)	-0.265 (0.26)	-1.192** (0.56)	1.132*** (0.16)	-4.703*** (1.30)	-4.554*** (0.77)
Log likelihood	-689.5	-558.3	-380.9	-748.0	-198.4	-126.4
Observations	366	366	366	366	366	366

*Note: * p<0.1; ** p<0.05; *** p<0.01*

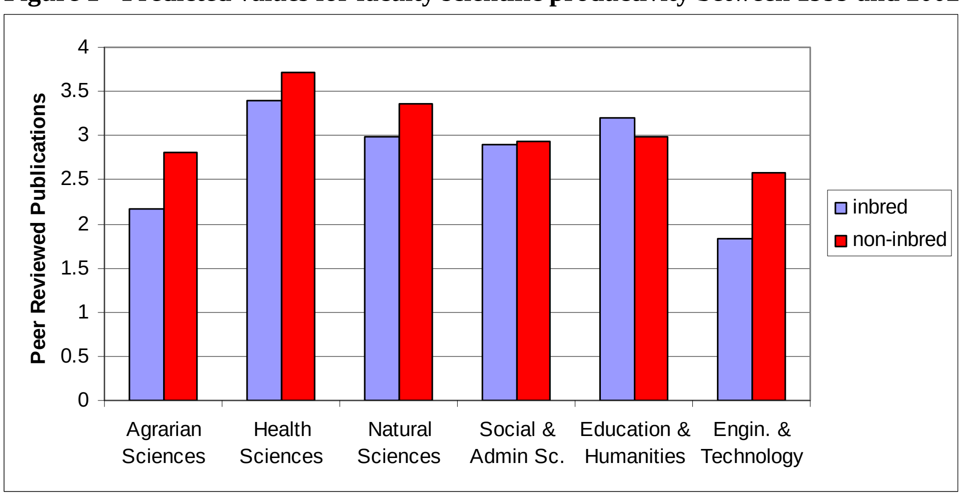
As it can be seen in Table 3, academic inbreeding has no impact on the production of teaching outputs (columns 1-3), as no statistically significant differences are found for the teaching output variables. This does not necessarily mean that inbreeding does not have an impact on the teaching and learning processes. Inbreeding may affect teaching practices, but if that effect exists, then it is not perceived through the number of thesis supervised. However, a statistically significant difference in research production is identified, with inbred faculty generating, on average, 15% fewer scientific papers than non-inbreds (column 4[11]). Interestingly, the results for scientific productivity contrast with those

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

associated with the outreach mission of the university, which we can proxy through the number of consultancy contracts, or the prototypes and patents. Inbred faculty appear to be more involved in outreach activities, generating 46% more consultancy contracts (column 5) and 8% more prototypes and patents (column 6) than their non-inbred peers.

Overall, results confirm the perceived notion in the literature that academic inbreeding practices are detrimental for the production of scientific outputs. As Figure 1 shows, this productivity gap persists across most areas of knowledge, albeit with different intensities. It seems to be especially relevant in the areas of engineering and natural sciences, with non-inbreds active in in engineering and technology generating close to 45% more publications. The negative effects of inbreeding are present also across the various institutions. In particular, our estimates (not shown in the article but available from the authors upon request) indicate that, even in more research oriented universities, the negative effects of academic inbreeding scholarly output remains, although with a smaller magnitude. This supports Berelson's (1960) and Hagstrom's (1971) arguments that the 'cosmopolitan' environment of leading research schools may minimize some of the detrimental effects of inbreeding. Yet, it does not eliminate the negative outcomes.

Figure 1 - Predicted values for faculty scientific productivity between 1999 and 2002



Note: Numbers reported are predicted values from the negative binomial regression model.

Results so far indicate that inbred faculty tend to favor the internal exchange of information when compared to non-inbred peers, and that inbred faculty produces less scientific outputs. These results validate hypotheses 1 and 2a proposed in section 2. Yet, while openness and scientific output are theoretically related, hypothesis 2b proposed that openness may indeed be a critical vehicle by which inbreeding conditions scientific productivity. To test this idea, we run the same regressions presented on Table 3, but adding "*external openness score*" as an additional independent variable. This allows us to test how scholarly outputs are affected by the external-internal orientation in terms of information acquisition and, at the same time, assess to what extent the inbreeding effects remain present when this additional control is considered.

Table 4 – Relationship between inbreeding, academic outputs and information exchange practices
Negative Binomial Fixed Effects Regression, Robust Errors

	(1) Supervision of undergrad thesis	(2) Supervision of master thesis	(3) Supervision of PhD Thesis	(4) Articles in peer review journals	(5) Consultancy (gov. or firms)	(6) Prototypes and patents
Inbreeding	**-0.005 (0.045)**	**-0.055 (0.12)**	**0.146 (0.12)**	**-0.113 (0.076)**	**0.957*** (0.30)**	**0.429*** (0.21)**
Years since first contract	0.002 (0.004)	0.020*** (0.004)	0.021** (0.008)	-0.014*** (0.004)	0.052*** (0.009)	0.045** (0.018)
Male	-0.009 (0.088)	0.293*** (0.092)	0.181 (0.12)	0.133*** (0.042)	0.857** (0.44)	1.471*** (0.54)
Participate collective R&D project	0.111 (0.15)	0.459 (0.31)	0.725*** (0.16)	0.295*** (0.093)	0.622* (0.35)	0.052 (0.29)
Funding for R&D last 3 years	0.031 (0.21)	-0.003 (0.17)	0.611** (0.26)	0.212** (0.086)	-0.401 (0.30)	0.868** (0.47)
Teaches undergraduate students only	-0.126 (0.21)	-0.811*** (0.14)	-0.873*** (0.26)	-0.256** (0.11)	0.439 (0.37)	-0.041 (0.30)
Teaches graduate students only	0.030 (0.36)	0.432* (0.24)	-0.332 (0.62)	-0.215 (0.22)	0.698 (0.77)	0.018 (1.08)
Average number of students per class	0.009 (0.008)	-0.004 (0.005)	-0.012** (0.006)	0.001 (0.002)	0.009 (0.011)	-0.018 (0.016)
External Openness Score	**0.026 (0.040)**	**0.036 (0.046)**	**0.120*** (0.036)**	**0.058*** (0.015)**	**-0.138 (0.11)**	**-0.238 (0.16)**
Constant	0.281 (0.50)	-0.188 (0.24)	-1.110* (0.59)	1.242*** (0.18)	-4.870*** (1.26)	-5.241*** (1.25)
Log likelihood	-663.0	-537.4	-365.7	-721.6	-194.6	-120.7
Observations	354	354	354	354	354	354

*Note: * p<0.1; ** p<0.05; *** p<0.01*

The results, presented in Table 4, show that the preference for external sources of information exchange impacts positively the production of two outputs: the supervision of doctoral thesis and the production of articles in peer review journals. This indicates that navel gazing practices, or favoring an internal exchange of information, has a negative impact solely on the research mission of the university, but not on the remaining missions. The analysis also shows that the preference of inbred faculty for exchanging information internally appears to be the critical issue associated with their lower scientific productivity when compared to their non-inbred peers. In fact, one can see in column 4 of Table 4 that the inbreeding variable becomes non-significant when the *external openness score* variable is included in the regression analysis. This means that the inbreeding variable does not appear to explain variance for the scholarly output variable beyond that explained by the variable measuring levels of openness. This result supports our H2b hypothesis, reinforcing the argument that inbred faculty are less productive due to their dependence on the internal knowledge acquisition. An external information exchange orientation does not appear to have an effect on outreach activities. This implies that inbred have other characteristics not related to information exchange that explain their greater outputs in consulting, patents and prototypes.

While the results presented so far seem to support our hypothesis, there is a potential issue of unobserved researcher heterogeneity related with our critical variable. In particular, it is possible that inbreeding is working as a proxy for inherent researcher ability. If this was the case, then we would be measuring the result of differences in ability rather than the inbreeding mechanism we are testing. While it is impossible to completely rule out this possibility, we will explore a different estimation approach to provide additional robustness to our results. To accomplish that, we consider the notion that, since openness appears to be the critical factor by which inbreeding impacts scientific productivity, one should find that time has an important influence in the results. In fact, the research network for the freshly mint PhD is typically dominated by the group where he or she completed graduate studies, regardless of their inbreeding status. Thus, we should expect very limited differences in output results between inbreds and non-inbreds early on in their careers. Yet, if the inbred faculty remains closed down around his or her graduate school environment, we should see research productivity results become progressively worse over time. On the contrary, if inbreeding is measuring inherent ability, we should see an effect that does not change over time. Since we know when each of the faculty completed the PhD, we can test this idea by interacting inbreeding with the variable measuring “years since first contract”, which is also part of our regressions. We expect to find that this interaction to be negative. Moreover, this should not be the case for the external openness measure because this attitude is contemporary to output and thus is in itself the result of the socialization process of each faculty over time. As a result, we should not find that a time interaction matters.

Table 5 – Robustness Checks for Inbreeding, scientific productivity and information exchange practices
Negative Binomial Fixed Effects Regression, Robust Errors

	(1) Articles in peer review journals	(2) Articles in peer review journals	(3) Articles in peer review journals	(4) Articles in peer review journals
Inbreeding	**-0.152** (0.069)**	**-0.113 (0.076)**	**0.228 (0.19)**	**-0.115 (0.078)**
Years since first contract	-0.012*** (0.004)	-0.014*** (0.004)	-0.007 (0.004)	-0.015*** (0.005)
Inbreeding * years since first contract	---	---	**-0.019*** (0.007)**	---
Male	0.155*** (0.043)	0.133*** (0.042)	0.154*** (0.046)	0.131*** (0.043)
Participate collective R&D project	0.265*** (0.085)	0.295*** (0.093)	0.260*** (0.076)	0.298*** (0.090)
Funding for R&D last 3 years	0.239*** (0.081)	0.212** (0.086)	0.220*** (0.079)	0.214** (0.086)
Teaches undergraduate students only	-0.265*** (0.097)	-0.256** (0.11)	-0.262*** (0.102)	-0.256** (0.103)
Teaches graduate students only	-0.132 (0.22)	-0.215 (0.22)	-0.158 (0.218)	-0.213 (0.224)
Average number of students per class	0.001 (0.001)	0.001 (0.002)	0.001 (0.001)	0.001 (0.002)
External Openness Score	---	**0.058*** (0.015)**	---	**0.089* (0.051)**
External Openness Score * years since first contract	---	---	---	**-0.002 (0.002)**
Constant	1.132*** (0.16)	1.242*** (0.18)	1.067*** (0.19)	1.278* (0.212)
Log likelihood	-748.0	-721.6	-745.7	-721.4
Observations	366	354	366	354

*Note: * p<0.1; ** p<0.05; *** p<0.01*

Table 5 presents the results of these new estimations. Since the focus of our paper is on scientific output, we include only the dependent variable of "articles in peer reviewed journals." To allow an easy comparison with the previous estimations, column 1 replicates the results presented in column 4 of table 3 and column 2 presents the results shown in column 4 in table 3. In column 3 we can see that, as expected, the interaction effect of inbreeding with time is highly significant, while the main effect loses statistical significance. This suggests that the negative effects of inbreeding are accrued over time. As expected, the effect of external openness, which is a contemporary measure, is not mediated by time.

The results so far confirm the general perception that academic inbreeding is detrimental to the performance of scholarly activities and research activities in particular. Yet, as explained, high rates of inbreeding are prevalent in many higher education systems worldwide. Hypothesis 3 suggests that such practices might result from particular institutional strategies.

Some of the results presented in Tables 3 to 5 provide some early support for this notion. As noted above, inbreds are much more active in external "outreach activities", including consulting contracts, as well as in the generation of prototypes and patents. Yet, one could think that these are performed solely due the individual pursuit of alternative sources of income, rather than an institutional strategy. To try to further explore the possibility that inbreds play particular non-research role in universities, we look at how inbreeding relates to enabling activities related to teaching and research rather than scholarly outputs. To do this, we will rely on a negative binomial regression discussed before, as well as on a probit where $\Pr(Y_{ijk} = 1) = \Phi(x_{ijk}'\beta + \alpha_j + \delta_k)$, such that Y_{ijk} = 1 indicates that the faculty member was engaged in such activity and zero otherwise. The individual controls as well as the area and institution effects are the same as those in previous estimations.

Table 6 – Relationship between inbreeding and some key research and teaching variables, Fixed Effects, Robust Errors

	Participates in collective R&D project? (1)	Has funding for R&D last 3 years (2)	Teach undergraduate students only? (3)	Teach graduate students only? (4)	Average number of students per class (5)
Inbreeding	-0.220 (0.24)	0.329 (0.23)	0.227*** (0.068)	-0.453** (0.22)	0.115*** (0.034)
Years since first contract	-0.005 (0.009)	0.001 (0.005)	-0.012** (0.006)	0.010 (0.017)	0.003 (0.003)
Male	0.066 (0.14)	0.161 (0.15)	-0.040 (0.12)	0.024 (0.29)	-0.088*** (0.030)
Constant	1.234** (0.46)	0.896*** (0.26)	-0.619 (0.24)	-1.976*** (0.53)	3.106*** (0.92)
Log likelihood	-200.4	-161.5	-213.6	-63.8	-1572.7
Observations	413	364	400	295	409

Note: Probit regressions used for columns 1-4. Negative binomial regression used in column 5

Table 6 shows that inbreds play a disproportionate role in activities that do not help their scientific productivity. In particular, inbred faculty are mostly allocated to teaching activities and more specifically teaching activities associated with lower levels of academic learning (i.e.: teaching at undergraduate levels). Inbred faculty are 32% more likely to teach undergraduate students only than non-inbreds, and 73% less likely to be teaching only graduate students. In addition to being mostly allocated to undergraduate teaching, inbred faculty also have a greater effort than non-inbred in terms of teaching engagement. Inbreds have 12% more students per course than non-inbreds. This allocation of time for inbreds versus non-inbreds is important because teaching activities, in particular time spent in undergraduate teaching, is expected to have a negative impact on scientific productivity (see Marsh and Hattie, 2002). These results support hypothesis 3, entailing the possibility for some degree of specialization of academic tasks, whereby inbred faculty are disproportionately associated with teaching and outreach activities, while non-inbred can devote more effort and time to research. This indicates that academic inbreeding may partially result from an institutional practice and perhaps even a strategy.

As proposed in Hypothesis 4, if a moderate presence of inbred faculty is the result of a strategy that aims at benefitting the research capabilities of the school, we should be able to find this effect in the data. Similarly, we should also be able to detect any negative impacts that a dominant presence of inbreds may have on non-inbreds .To test these ideas we explore how the average rate of academic inbreeding for each institution and scientific field conditions the research output of non-inbred faculty. For that purpose we estimate a negative binomial model, similar to the one used in the estimations presented in Table 3, but consider only the subset of faculty that are non-inbred. Then, instead of including an individual dummy that signals the inbreeding status of the faculty member, we consider the average level of inbreeding in the field and institution of the focal individual. Finally, since we expect the effect to be non-linear, we also consider the square of this measure in the regression.

Table 7 – Effect of academic inbreeding on the scientific output of non-inbred faculty; Negative binomial regression, Fixed Effects, Robust Errors

*Considering only **Non-inbred faculty***	Articles in peer review journals
Average Inbreeding per scientific area and institution	3.335*** (1.06)
Average inbreeding per scientific area and institution squared	-5.205*** (1.58)
Years since first contract	-0.008* (0.004)
Male	0.175*** (0.052)
Participate collective R&D project	0.308*** (0.12)
Funding for R&D last 3 years	0.185** (0.077)
Teaches undergraduate students only	-0.179** (0.074)
Teaches graduate students only	-0.200 (0.30)
Average number of students per class	0.0001 (0.002)
Constant	0.867*** (0.31)
Log likelihood	-547.9
Observations	269

*Note: * p<0.1; ** p<0.05; *** p<0.01*

Table 7 presents the results of the estimates. As it can be seen, the coefficient on the linear term of the inbreeding variable is positive, while the squared value is negative. This means that, as hypothesized, initial rates of inbreeding in higher education institutions might be beneficial in terms of research output. Yet, as the presence of inbreds increases, this effect becomes detrimental. Moreover, the coefficients on the regressors place the effect within a reasonable range. Our estimates suggest that the output benefit for non-inbreds grows until the inbreeding rate is 32%, reaching an average output that is close to 50% larger than their baseline. After that, the effect starts to decline and becomes negative when the inbreeding rate reaches 65%, after which non inbreds see a decline in their rate of scientific output.

5. Discussion

Overall the analysis finds that inbreeding has a negative impact on individual scientific outcomes. An inferior scientific productivity for academic inbreds appears to be prevalent across institutions and areas of knowledge. Moreover, results suggest that the detrimental effect of inbreeding in research is centered in the inbred academic's lack of information exchange outside their institution. This finding reinforces previous analyses emphasizing the notion that the generation of new knowledge requires combining existing and emergent knowledge, with most of the latter residing outside the organization (Kogut and Zander, 1992; Fleming and Sorenson, 2004). It also complements existing literature underlining personnel mobility as beneficial for the generation of knowledge (Gruenfled et al., 2000) and its transference (Almeida and Kogut, 1999). Consistent with Song et al. (2003) and Lacetera et al. (2004), our results suggest that hiring faculty and recent doctorates from other universities brings outside linkages that are associated to new methods, as well as novel forms of thinking and doing research. But we go further by showing that such phenomenon can be traced to individual practices and outcomes, rather than being the result of an abstract organizational process. First, we show that mobility strategies are reflected in levels of research productivity, rather than only on access to specific knowledge or research direction, as explored in previous work. Second, we demonstrate that external openness to information exchange is the key mechanism that helps understand such differences. Moreover, we also show that the negative impact of inbreeding on output happens progressively, as inbreds fall behind on the evolution of the scientific knowledge. These two latter aspects had not been explored by prior work.

The early results open a critical question that had not been addressed in prior research: why do universities hire their own faculty if such practices are thought to be associated with inferior scientific productivity? Our analysis suggests that a small degree of inbreeding could be the result of an institutional strategy, such that non-inbred faculty mostly focus on research activities and inbred faculty contribute disproportionately more for teaching and outreach. In particular, inbreds are allocated higher teaching loads and larger undergraduate classes. Similarly, they are more involved in consultancy contracts with government and private firms. Since teaching or outreach are mutually exclusive with research activities (Marsh and Hattie, 2002), the presence of some inbred faculty could generate a positive impact in the broad institution by improving the output of the research faculty. The results show that, in fact, moderate levels of inbreding can have a positive impact in the research output of non-inbreds. This effect is significant and thus it is plausible to consider that it can outweigh the inferior outputs that inbreds will generate. This dimension, coupled with other factors such as information asymmetry for outside faculty applicants, especially in early stages of development of a scientific system, provides a clear rationale for schools to decide to hire their own PhD graduates, at least to some extent..

The problem with this strategy emerges when a careful and limited institutional solution becomes an established recruitment practice and inbreeding rates start to grow. Our findings show that, as the presence of inbreds becomes dominant, there are important spillovers affecting non-inbreds, who see their productivity declining. This result can be understoon if one reflects on the organizational processes that will be taking place. Inbreds have a dramatically higher propensity to favor internal information exchanges, thus curtailing linkages to external sources. These linkages are critical for organizations (see Pfeffer and Salancik, 1978; Nelson and Winter, 1982; Cohen and Levinthal, 1990) and perhaps even more for universities, which rely intensely on advanced knowledge (Nowotny et al., 2001). As a university hires more inbreds, inward driven organizational practices consolidate (Frans *et al.*, 1999), resulting in linkages with the outside becoming increasingly scarce and ultimately at odds with the prevailing culture. Progressively, faculty are like to become less open to acquire new knowledge, different methodologies or frameworks other than the ones that they are accustomed to work in.

The potential effect can be summarized by the words of Cohen and Levinthal (1990): "If all actors in the organization share the same specialized language…they may not be able to tap into diverse external knowledge sources". This further makes them rely on what they know and share within the university. Such knowledge will gradually depreciate (Argote, 1999) and become obsolete, to a point where its novelty and usefulness to the scientific enterprise is minimal As a result, existing institutional culture and *status quo* is likely to be preserved, leading to a constrained organizational knowledge in terms of scope and flexibility (Camerer and Vepsalainen, 1988). In extreme situations, it could originate the establishment of 'mental prisons' that impede change or slow it in favor of organizational and knowledge inertia (Leeuw and Volberda, 1996). This can ultimately place the university legitimacy and social utility in jeopardy (Scott, 1995). It is well know that social worthiness and rapid response to demands and requests from the external environment are often critical in assuring the survival of organizations, and universities would be no exception (Heitor and Horta, 2004; Scott, 1995). In fact, external research links support the critical role of the university as a source knowledge and active contributor to local industry innovation (e.g.: Henderson et al., 1998). As a result, the progressive closure of the university is likely to be especially damaging to this role of the university as contributor to the scientific and economic outcomes of a region.

The fundamental problem is that this process of closure and alienation is likely to take place over a long period, as the practice of inbreeding gets institutionalized and the overall faculty gradually turns inward. Therefore, it is difficult to clearly know when inbreeding and its pernicious effects become the dominant force over the potential benefits associated with teaching and outreach that may result from hiring own graduates. Such a process would help explain how universities and entire national systems can be driven to an inbreeding trap, from which it may be difficult to exit.

6. Conclusions

The analysis demonstrates that academic inbreeding is detrimental to individual scientific productivity. Inbred faculty generate fewer articles in peer reviewed journals than non inbred faculty across institutions and most areas of knowledge. These negative impacts appear to be particularly salient in natural sciences, engineering and technology. Moreover, the lack of exchange of information with the exterior of the university appears to explain the lesser scientific output of inbred faculty. Yet, the analysis also shows that having universities recruiting a small fraction of faculty among their own graduates can be a sensible institutional strategy. By shouldering disproportionately heavier teaching and outreach responsibilities, inbreds can have a positive impact on the average productivity of non inbreds and thus benefit the overall research output of school. But this potential gain has a clear limit because a growing presence of inbreds will naturally erode any benefits brought to a shrinking fraction of non inbreds. Furthermore, because closed groups tend to consolidate and reinforce existing social structures, an excessive dependence of universities in inbred talent will lead to a dominant culture of navel gazing and ultimately have negative effects also in non inbreds. This culture is likely to lead to academic fossilization and knowledge atrophy. Since these processes unfold over a long time, allowing for some inbreeding brings the danger of placing universities in a slow moving trap whose shorter term benefits occlude the longer term insidious impacts.

Overall, our analysis strongly suggests that a small presence of inbreeding, as often found in US or UK institutions, can be beneficial to scientific productivity, but widespread inbreeding practices should be countered and probably prevented. Universities should assure periodic renewing of their core faculty with professors trained in other institutions and schools or governments need to provide strong incentives towards mobility related to career progress, perhaps considering establishing limits for the presence of inbreds among faculty.

Despite the consistent findings, it is important to remember that this study was developed using data from Mexico. While this emerging science and technology system is comparable to many regions around the world now developing their own systems, it also limits extrapolations and direct applications to more advanced contexts. In fact, it is possible that, as they progress, systems develop mechanisms and instruments to prevent the navel gazing process that is associated with inbreding, breaking at least an important part of the negative cycle. Further work looking at intermediate systems such as the Spanish or Portuguese could provide very valuable insights in what regards the generalizability of these findings.

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ANNEX – Correlation Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
external openness score (1)	1																
Number of undergraduate thesis supervised (2)	0.03	1															
Number of master thesis supervised (3)	0.09	0.07	1														
Number of PhD thesis supervised (4)	0.11	0.03	0.41	1													
Number of articles in peer reviews journals (5)	0.14	0.14	0.00	0.06	1												
Prototypes and patents (6)	-0.11	0.01	0.02	0.09	-0.03	1											
Number of consulting contracts (7)	-0.07	0.05	0.10	0.13	-0.06	0.07	1										
Conduct/participate collective R&D project (8)	-0.01	0.01	0.12	0.14	0.15	0.00	0.03	1									
Had funding to develop R&D in the last 3 years (9)	-0.03	-0.01	0.04	0.17	0.16	0.08	-0.03	0.18	1								
Teaches undergraduate students only (10)	-0.16	-0.05	-0.26	-0.19	-0.14	0.00	0.04	-0.02	-0.05	1							
Teaches graduate students only (11)	0.12	-0.02	0.18	-0.06	-0.07	-0.03	0.04	-0.05	-0.09	-0.12	1						
Average number of students per class (12)	-0.12	0.09	-0.10	-0.10	0.02	-0.07	0.00	0.00	0.01	0.02	-0.15	1					
Years since first job in academia (13)	-0.01	0.09	0.19	0.20	-0.12	0.08	0.19	0.01	0.01	-0.06	-0.10	0.00	1				
Male (14)	0.00	-0.02	0.16	0.04	0.04	0.14	0.10	0.00	0.07	0.00	0.00	-0.12	0.07	1			
Inbreeding (15)	-0.20	0.05	-0.05	0.05	-0.05	0.05	0.16	-0.03	0.09	0.02	-0.08	0.11	0.08	-0.07	1		
Inbreeding per scientific area and institution (16)	-0.16	0.06	0.10	0.21	0.00	0.02	0.19	0.06	0.13	-0.08	-0.13	0.05	0.31	0.02	0.44	1	
Agrarian sciences (17)	0.04	-0.03	0.02	0.04	-0.02	0.00	0.10	0.00	0.02	0.02	-0.03	-0.13	-0.03	0.02	-0.04	-0.02	1
Health sciences (18)	-0.05	-0.03	0.07	0.10	0.08	-0.01	-0.05	0.04	0.03	0.01	-0.04	0.14	0.02	-0.06	0.13	0.27	-0.05
Natural sciences (19)	0.03	-0.13	-0.20	-0.07	0.08	0.06	-0.16	0.10	0.09	0.04	-0.07	0.04	-0.11	0.04	-0.11	-0.26	-0.11
Social sciences (20)	0.11	0.07	0.02	0.05	-0.02	-0.09	0.08	-0.16	-0.12	-0.08	0.05	-0.06	0.07	-0.11	0.01	0.01	-0.07
Humanities sciences (21)	-0.03	0.04	-0.02	-0.02	0.00	-0.03	0.02	-0.03	-0.08	-0.01	-0.03	0.12	0.03	-0.14	0.08	0.18	-0.05
Engineering (22)	-0.10	0.09	0.17	-0.03	-0.14	0.05	0.10	0.03	0.05	0.02	0.10	-0.15	0.04	0.21	-0.02	-0.04	-0.07
hei3 (23)	0.06	-0.15	0.09	-0.04	-0.02	-0.05	0.00	-0.10	0.01	-0.10	0.24	0.00	-0.18	-0.06	-0.08	-0.18	-0.03
hei19 (24)	-0.02	0.03	-0.01	0.09	0.11	-0.04	0.04	0.03	0.00	0.02	0.03	-0.07	0.06	-0.08	-0.07	-0.04	-0.03
hei21 (25)	-0.04	0.10	0.04	-0.10	-0.06	-0.05	0.02	-0.04	-0.05	0.00	0.13	-0.05	-0.04	0.09	-0.08	-0.17	-0.04
hei22 (26)	0.06	-0.06	0.01	-0.06	-0.07	-0.02	0.00	0.04	-0.19	-0.05	-0.02	-0.07	0.05	-0.06	0.01	-0.09	-0.01
hei23 (27)	0.02	0.02	-0.01	0.06	0.09	0.00	-0.13	0.04	0.06	0.04	-0.13	0.10	0.04	-0.03	-0.11	-0.25	-0.08
hei27 (28)	-0.13	0.00	0.05	0.15	0.04	0.03	0.11	0.02	0.11	-0.07	-0.08	0.02	0.24	0.05	0.35	0.72	-0.11
hei28 (29)	0.05	0.00	-0.02	-0.03	-0.05	-0.03	-0.01	0.05	-0.07	-0.06	-0.03	0.10	-0.03	-0.07	-0.07	-0.02	-0.02
hei42 (30)	0.05	-0.03	-0.01	-0.10	-0.06	0.06	0.03	0.04	0.02	0.04	0.02	-0.10	-0.13	0.11	-0.05	-0.13	0.30
hei51 (31)	0.11	-0.01	-0.17	-0.06	0.05	0.07	-0.07	0.03	-0.04	0.02	0.05	-0.15	-0.23	0.00	-0.09	-0.20	0.05
hei56 (32)	0.02	-0.09	0.02	-0.07	-0.16	0.02	-0.01	-0.04	-0.06	0.00	0.04	0.05	-0.12	0.04	-0.06	-0.14	-0.02
hei63 (33)	0.16	-0.01	-0.04	-0.08	0.01	-0.02	-0.03	-0.06	-0.07	0.05	0.03	-0.02	-0.01	-0.06	-0.08	-0.18	-0.03
hei68 (34)	0.01	0.06	-0.02	-0.06	0.05	-0.04	0.02	0.00	0.02	-0.03	-0.03	0.09	-0.06	-0.03	-0.04	-0.09	-0.02
hei75 (35)	-0.03	-0.05	0.06	0.07	-0.05	0.01	0.08	0.05	0.00	0.05	-0.03	-0.06	0.01	-0.01	-0.07	-0.07	0.50
hei84 (36)	-0.12	0.08	-0.05	-0.10	-0.14	-0.04	-0.05	-0.10	-0.12	0.10	-0.04	0.06	0.02	-0.05	-0.01	-0.02	-0.02

Table A1 – Correlation table

	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
Health sciences (18)	1																		
Natural sciences (19)	-0.28	1																	
Social sciences (20)	-0.17	-0.37	1																
Humanities sciences (21)	-0.12	-0.26	-0.16	1															
Engineering (22)	-0.18	-0.40	-0.24	-0.17	1														
hei3 (23)	-0.02	-0.15	0.35	-0.06	-0.10	1													
hei19 (24)	-0.06	-0.14	0.29	0.05	-0.09	-0.03	1												
hei21 (25)	-0.10	-0.11	-0.14	-0.06	0.41	-0.05	-0.05	1											
hei22 (26)	-0.03	-0.07	0.19	-0.03	-0.05	-0.02	-0.02	-0.03	1										
hei23 (27)	-0.12	0.07	-0.03	0.02	0.04	-0.10	-0.10	-0.16	-0.05	1									
hei27 (28)	0.23	0.04	-0.09	0.01	-0.11	-0.15	-0.14	-0.23	-0.07	-0.45	1								
hei28 (29)	0.11	-0.09	0.00	0.04	0.00	-0.02	-0.02	-0.03	-0.01	-0.07	-0.10	1							
hei42 (30)	-0.02	0.10	-0.09	-0.06	-0.06	-0.04	-0.04	-0.06	-0.02	-0.11	-0.16	-0.02	1						
hei51 (31)	-0.09	0.21	-0.12	-0.04	-0.06	-0.05	-0.04	-0.07	-0.02	-0.14	-0.20	-0.03	-0.05	1					
hei56 (32)	-0.06	-0.13	0.01	0.07	0.14	-0.03	-0.03	-0.05	-0.01	-0.09	-0.13	-0.02	-0.03	-0.04	1				
hei63 (33)	-0.07	0.08	0.03	0.04	-0.10	-0.04	-0.03	-0.05	-0.02	-0.10	-0.15	-0.02	-0.04	-0.05	-0.03	1			
hei68 (34)	0.08	0.02	-0.07	0.02	-0.02	-0.03	-0.03	-0.04	-0.01	-0.08	-0.11	-0.02	-0.03	-0.03	-0.02	-0.03	1		
hei75 (35)	-0.04	-0.04	-0.06	0.04	-0.06	-0.02	-0.02	-0.03	-0.01	-0.07	-0.10	-0.01	-0.02	-0.03	-0.02	-0.02	-0.02	1	
hei84 (36)	0.07	-0.08	0.07	0.01	-0.03	-0.03	-0.03	-0.04	-0.01	-0.08	-0.12	-0.02	-0.03	-0.04	-0.02	-0.03	-0.02	-0.02	1

Table A1 – Correlation table (continuation)