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Navel Gazing: Academic Inbreeding and Scientific Productivity

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The practice of having Ph.D. graduates employed by the university that trained them, commonly called "academic inbreeding," has long been suspected to be damaging to scholarly practices and achievement. Despite this perception, existing work on academic inbreeding is scarce and mostly exploratory. Using data from Mexico, we find evidence that, first, academic inbreeding is associated with lower scholarly output. Second, the academically inbred faculty is relatively more centered on its own institution and less open to the rest of the scientific world. This navel-gazing tendency is a critical driver of its reduced scientific output when compared with noninbred faculties. Third, we reveal that academic inbreeding could be the result of an institutional practice, such that these faculty members contribute disproportionately more to teaching and outreach activities, which allows noninbred faculty members to dedicate themselves to the research endeavor. Thus, a limited presence of inbreds can benefit the research output of noninbreds and potentially the whole university, but a dominantly inbred environment will stifle productivity, even for noninbreds. Overall, our analysis suggests that administrators and policy makers in developing nations who aim to develop a thriving research environment should consider mechanisms to limit this practice.

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1. Introduction

At the beginning of the 20th century, it was common to find major U.S. land grant universities (McNeely 1932) and Ivy League institutions (Handschin 1910) where a large proportion of the students would stay as faculty after completing their Ph.D. degrees. This practice of hiring your own, commonly called "academic inbreeding," has long been suspected to have a damaging effect on scholarly practices and achievement (Berelson 1960, Pelz and Andrews 1966). In 1908, when 64% of Harvard faculty were home-grown graduates, president Charles W. Eliot (1908, p. 90) warned that inbreeding presented "grave dangers for a university." Historical studies suggest that, even then, inbred faculty had less recognition, both academic and economic, as well as lower levels of achievement and promotion when compared with noninbreds (Eells and Cleveland 1999, Reeves et al. 1933).

Academic inbreeding continues today in some U.S. 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 U.S. academic system has evolved, the overall level of inbreeding has declined to less than 20% and is often below 10%. A similar pattern is seen in the United Kingdom (Navarro and Rivero 2001). In contrast with these two nations, inbreeding is regarded as the norm in many countries, especially those with emergent scientific systems. Estimates suggest that academic inbreeding in Spain is as high as 95% (Navarro and 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 universities (Yamanoi 2005).

The existence of severe inbreeding environments in a variety of countries now aiming to become centers of high-level scholarly research raises critical questions about the real impact of this practice on universities (Navarro and Rivero 2001, Soler 2001). This has been recognized in the European Commission's white paper on education and learning (European Commission 1995), which identified academic inbreeding as a worrisome problem for the European research community. Yet, because of its decline in importance within leading research nations, the interest in academic inbreeding from a research perspective has waned. As a result, analysis of this issue has been either exploratory or a marginal item in the context of a broader study (Soler 2001, Wyer and Conrad 1984, Hargens and Farr 1973, McGee 1960).

A proper understanding of the impact of academic inbreeding is clearly of direct interest to university administrators and policy makers in the areas of science, technology, and higher education. But the relevance is more far reaching. University research functionality is critically relevant to local industry innovation (e.g., Henderson et al. 1998); it has been found, for example, to have an influence on local patenting rates (Jaffe 1989, Acs et al. 1992). It has also been shown that leading firms in several high-tech sectors depend on strong academic research taking place in a university research environment (Furman and MacGarvie 2007, Nelson 1993, Spencer 2001, Zucker and Darby 2006). Thus, a potentially negative impact (from academic inbreeding) on university research output and quality may play a role in critically limiting the scientific and economic outcomes of a region or an entire nation.

Studying the impact of academic inbreeding on 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 growing literature on this topic suggests that hiring external researchers into existing environments is an important way to enhance 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 interfirm knowledge transfer, whereas 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 those scientists who never change their research environment compared with those who are mobile.

This paper assesses the impact of academic inbreeding on scholarly practices and achievement using a unique data set that includes Mexican scientists, their characteristics, behaviors, and outputs. This research makes several contributions. We start by establishing an empirical setting that clearly shows that inbred researchers have less research output than their noninbred counterparts. The study takes into account individual faculty heterogeneity in terms of ability and diversity of institutional environments, and also considers a variety of controls for allocated teaching duties and other university or external activities. Our analysis confirms prior assumptions about the negative impacts of inbreeding. We then go on to explore 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 an inbred faculty, whose members are much less likely than their noninbred colleagues to focus their exchange of scholarly 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, although inbred faculty may display lower scientific productivity, our results show they can fulfill other missions of the university, in particular, in the areas of teaching and links to the business environment. Moreover, our findings suggest that retaining some inbreds may be sensible because they can free up the time of noninbreds to concentrate on research and thus contribute to overall productivity. Yet, the analysis also shows that as the presence of inbreds becomes dominant, their culture will ultimately affect noninbreds and lead to a reduction in their research output.

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., the Reeves et al. (1933) study of the University of Chicago, the Hollingshead (1938) study of Indiana University, and the McNeely (1932) study of land grant universities). They typically present descriptive statistics of the universities and their faculties, including the topic of academic inbreeding. These studies note that inbred faculty typically display lower levels of achievement when compared with noninbred faculty, but they do not attempt to estimate such effects. Then, in 1966, Pelz and Andrews published their important sociological study of scientists, where they suggested two fundamental notions associated with the potential negative impact of academic inbreeding. First, they stated that a critical issue with inbreeding hinges on the idea that inbred faculty are less creative, independent, connected, and original than noninbred faculty. Second, as a result of this notion, they suggest that inbred academics will be less productive and make a lower scientific impact. Again, they do not empirically estimate these two notions.

The limited literature addressing academic inbreeding since the 1960s has typically focused on analyzing its impact on scientific productivity and has overlooked the original 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 are more likely to display low levels of communication with other scientists, as well as a preference to interact with colleagues at their own institution rather than with colleagues from other universities and research and development (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 undertaken by McGee (1960). Although he concluded that inbred faculty were more productive than noninbreds, his work lacked controls for important confounding factors, which limited the validity of his conclusions (see the critique by Lieberson and Gold 1961). Subsequent research by Hargens and Farr (1973) finds inbred faculty to be associated with reduced scientific output when compared with noninbreds. 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. They find that the research productivity of inbred and noninbred faculty is very similar. An important difference to prior work is their attempt to control for the effects of research versus teaching time allocation by dividing the rate of publications per career year by the amount of time spent, as reported by each faculty member, on research and teaching activities. Yet, similarly to previous research, their estimation also does not include individual or institutional controls. One of the most recent notes on the issue was published by Soler (2001). He relates the productivity of 51 ecology and zoology departments in Europe to their levels of academic inbreeding: he found a negative correlation.

In sum, many studies on academic inbreeding rely mostly on descriptive statistics. Others use univariate methods to assess the effects of inbreeding on scholarly results. As a result, they lack critical controls that could explain the observed differences in achievement between inbreds and noninbreds. For example, in a system where inbreeding is a recent phenomenon, inbreds may publish less because they are more junior and not because they stayed in the same school where they gained the Ph.D. Thus, an analysis that does not control for seniority could wrongly attribute a gap in productivity to inbreeding, when it could result from differences in experience. Our work addresses these issues by carefully controlling for critical confounding factors that condition the productivity of individual researchers. In addition, it also tackles two other fundamental aspects not yet explored. First, it focuses directly on the factors that might explain differences in productivity between inbreds and noninbreds. Second, it addresses the question of why universities would hire inbreds if the perception is that they are less productive researchers.

2.2. Hypotheses

Pelz and Andrews (1966) advanced the untested notion that inbred faculty are less creative, independent, connected, and original than noninbred 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 the individual level, inbred faculty members carry out their academic and scholarly activities within a framework of extreme dependence on internal networks and on preestablished 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 same university, his activities become so embedded in the organizational culture and modus operandi that he may not feel the need to look for information elsewhere (Pelz and Andrews 1966). Thus, the first hypothesis is as follows:

Hypothesis 1 (Openness Hypothesis). *Noninbred faculty members are relatively more likely to exchange scholarly information outside rather than inside their university compared with inbred faculty members.*

The second critical notion of the literature, also articulated by Pelz and Andrews (1966), is that academically inbred faculty members will produce less scientific output compared with noninbred 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 (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) that inform them about how to learn and accumulate relevant knowledge (Cohen and Levinthal 1990), and how to understand the rules of the game (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 Andrews (1966), if the individual inbred academic faculty member is less connected with the exterior world, they will have difficulties in refreshing their knowledge base. Because knowledge depreciates (Argote 1999), it is reasonable to argue that with time the knowledge of inbred faculty members will become increasingly outdated. This is bound 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 up the organization to new knowledge (Song et al. 2003, Lacetera et al. 2004). This is seen as a way to balance the typical dependent and localized search processes that individual researchers undertake in knowledge-intensive environments (Stuart and Poldony 1996, Rosenkopf and Nerkar 2001, Singh 2005). This leads to our second hypothesis:

Hypothesis 2A (Productivity Hypothesis). *Inbred faculty members produce fewer scientific outputs than noninbred 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 in terms of the link between inbreeding and productivity at the individual level. If excessive reliance on internal knowledge (i.e., navel gazing) impacts scientific output, we should expect the following:

Hypothesis 2B (Openness–Productivity Hypothesis). *Inbred faculty members produce fewer scientific outputs than noninbred faculty members because they tend to favor internal scholarly information exchanges over external scholarly information exchanges.*

Inbreeding has long been seen by most literature and institutions as having negative consequences (see European Commission 1995). Thus, a critical question is, why would universities hire inbreds if they are likely to have an inferior scientific performance? This issue has been sidelined in previous work.

One perspective could be that academic inbreeding is a phase of development in higher education systems. The evolution of the U.S. system could lend some support to this notion. Another observation consistent with this idea is the fact that higher rates of academic inbreeding have historically been found in leading national research universities, i.e., those where a country's first doctoral programs 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 stage of development may not be a sufficient explanation for the practice. Thus, it seems likely that inbreds are playing specific roles or bringing other benefits to higher education institutions.

The reasoning that inbreeding is perhaps part of an institutional strategy becomes more apparent if one reflects on how a university might benefit from the characteristics of its recent doctoral graduates. These were socialized in the organizational routines of the university where they studied, are aware of its culture, and are likely to know its curricula and lecturing style very well. Thus, they can enter the institutional setting and start teaching there with relative ease. Moreover, they are readily available for employment and with some quality assurance vis-à-vis unknown external applicants. For recent doctorates, this is an attractive 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 tend to treat inbreds and noninbreds differently. This possibility has been noted in prior studies. For example, an early report prepared for the U.S. Office of Education (McNeely 1932) found slightly lower salaries for inbred faculty compared with noninbred faculty. This perspective was later reinforced by McGee's (1960) study of the University of Texas. According to McGee (1960), the university positively discriminated in favor of noninbred faculty in terms of salaries so that it could be competitive in national higher education labor markets and attract faculty with higher scholarly (and especially research) potential. Consistent with the notion that the university was doing this as a strategy, he also noted that inbred faculty are allocated a higher teaching load than noninbred faculty.

Nowadays, it is the research mission that lends 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 standing of the university within the national innovation system (see Cummings 1998). Thus, it is reasonable to expect that higher education institutions will allocate easily available faculty (i.e., their own graduates) to teaching and "outreach" activities while noninbred faculty members preferably engage in research, an activity where they can excel. Thus, we can advance a third hypothesis:

Hypothesis 3 (Inbreeding Hiring Hypothesis). *Inbred faculty are hired under a resource management strategy to perform a disproportionately larger share of tasks related to the teaching and outreach missions of the university.*

If the presence of inbred faculty allows noninbreds to concentrate more on research activities, where they are more productive, we should be able to see this reflected in the research output. Thus, we may find that a small presence of inbreds may have a positive effect on 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 limitation to this benefit. First, because 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 bestow on noninbreds. Second, we should also expect the growing presence of inbreds to affect the output of noninbreds. As the number of a university's own graduates increases, the university will be fostering the dissemination of locally learned knowledge and practices, as well as a consolidation of the organization's social structures (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 ascribe less importance to the demands of complex and swiftly evolving external knowledge (Nowotny et al. 2001), these might impede the renewal of the academics' pool of knowledge across the whole university. This means that the effects will not be confined to the individual, but rather will percolate through the organization as a whole. This will ultimately be reflected in the output and quality of the research work of all the researchers in the organization, including the noninbreds. In this context, we will consider that there could be an inverted-U relationship between the presence of academic inbreeding, the level of productivity, and the noninbred faculty members:

Hypothesis 4 (Organizational Productivity Hypothesis). *Low rates of academic inbreeding will have a positive impact on the productivity of noninbreds, but high academic inbreeding rates will affect their scientific productivity negatively.*

3. Data

3.1. Source and Characteristics

The data set used in this study was generated through a survey conducted to analyze the impact of public policies on processes of institutional change within Mexican higher education institutions. Mexico's scientific system is particularly suitable for the study of academic inbreeding because its size, diversity, and level of development are comparable to a variety of other emerging nations around the world (Gonzalez-Brambila and Veloso 2007). Yet, it is important to note that the origin of the data may also limit our ability to extrapolate results to more mature environments, such as the United States or the United Kingdom, which may have developed alternative mechanisms to deal with the potentially 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 data set 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 [The National Association of Universities and Higher Education Institutions]). 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 came from 64 higher education institutions and all scientific fields.[1]

Given the purpose of our analysis, this data set was filtered according to two requirements. The first was to include only faculty holding a Ph.D., because the alma mater Ph.D. was used to distinguish inbreds from noninbreds. The second requirement was to consider only higher education institutions that granted doctoral degrees, because if an institution did not do so, all faculty in that school would necessarily be noninbred. This filtering resulted in 414 academics from 14 higher education institutions.

In our analysis, an academic is considered inbred if he or she was first hired and developed a career in the very same higher education institution where their doctoral degree was obtained (Berelson 1960). In our data, we characterized an academic as an inbred if the Ph.D.-granting institution was the same institution in which their academic career started, and also represented where the academic was currently based. This minimized the possibility of mistakenly

[1] For further information on the sampling methodology, see Grediaga et al. (2004).

Table 1 Descriptive Statistics for All the Variable Categories

	Obs.	Mean	Std. dev.	Min	Max
Information exchange					
Information exchange practices/relative external openness score	398	−1.11	1.64	−5	5
Scholarly outputs					
Number of undergraduate theses supervised	409	1.99	2.17	0	9
Number of master theses supervised	409	1.41	1.54	0	6
Number of Ph.D. theses supervised	409	0.65	1.05	0	4
Number of articles in peer-reviewed 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 three 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

Note. All values refer to totals for years 1999–2002.

categorizing as inbred faculty those holding a Ph.D. from the same institution where they currently work but that have previously held a position in another school.[2] These academics 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 superior in a scholarly sense and very competitive in the academic labor market (Caplow and McGee 1958, Calhoun et al. 1990). Defined thus, academically inbred faculty represented 26% of our sample, with strong variation across institutions and areas of knowledge.

3.2. Variables

The analysis used 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 in Table 1.

The first variable is a *measure of information exchange practices* or, more synthetically, a *relative external openness score*. It represents the degree to which an academic has a relative preference to exchange information inside their institution, which is reflected in a more negative score, or outside it, reflected with a larger positive score. This variable is constructed from the inclusion of several questions on information exchange. Faculty were asked to report on their information exchange practices in six categories relating to the subject of the exchange: research and teaching activities, innovative subjects and articles, equipment and research techniques, financial sources for research, publishing and diffusion of research results, and, finally, job vacancies. For each category, the survey asked the academic what his or her level of intensity in information exchange was 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 from other national institutions and academics 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 whether faculty favored information exchange inside or outside the university where they currently work, we created a scale based on the sum of two external questions 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 exchanges information within their own research group (score of −4) and within the university (−4), but who rarely exchanges information with national peers (2) and never with contacts outside the country (1), would obtain a score of −5, whereas an academic that frequently exchanges information with colleagues outside the university, both nationally (4) and internationally (4), and who also frequently exchanges information with colleagues from his or her research group (−4) and sometimes within the broader institution (−3) would accrue a score of 1. This resulted in six scores for information exchange, one for each of the categories considered in the questionnaires. The variable used in our estimation, *relative external openness score*, is the average of the six scores.[3] As 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

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

[3] We also performed an analysis using individual scores and the results were very robust across the various individual measures.

the mission of the university—education, research, and outreach. The data for these variables was obtained directly from the questionnaire; this asked each academic about their output, along each of the relevant dimensions, over the three academic years 1999–2002. The output variables associated with education were the *number of theses at undergraduate, masters, and Ph.D. levels supervised by the faculty* (although at the Ph.D. level, the output represents a mix between teaching and research). Research output was assessed using the *number of articles in scientific peer-reviewed journals*.[4] To characterize outreach work, we used the *number of consulting contracts* as well as the *number 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.[5]

Another set of variables critical to the analysis relates to the allocation of effort by academics. In addition to being a measure of the academics' willingness or ability to perform particular activities, these variables also provide a snapshot of the tasks assigned to the academics in their various institutions. The first variable of this group is *participation in collective R&D projects*, which indicates the degree of engagement of the faculty member in scientific research networks. 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% did receive it). This provides information on the availability of resources to support research outputs.[6]

We were also able to gather information on teaching activities. These include whether the academic is *teaching undergraduates only* (24%), *teaching graduates only* (5%), or *teaching 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 that the faculty member has to undertake. Previous analyses of institutional inbreeding highlight the importance of considering these activities when studying the effects of inbreeding on scientific outputs (e.g., McGee 1960, Wyer and Conrad 1984).

The fourth category is key demographics. The first variable is the *number of years since the first job in academia*, which can be a measure for the experience of the faculty.[7] The average length of faculty experience 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 *inbreeding*. This is an indicator variable at the individual level of inbreeding, which takes the value of 1 if the faculty is inbred. As noted above, academically inbred faculty represented 26% of our sample.

3.3. Additional Data: Reaction Interviews

We also conducted a dozen interviews with university managers and administrators, including current and former rectors, deans of schools, and department chairs. The interviews had three components. First, we asked general questions aimed at gaining an understanding of the interviewee's overall perceptions about the issue of academic inbreeding. Then, we presented the main results of our study and discussed them with the interviewees. Finally, we focused on the interviewee's institution, discussing whether respondents believed that inbreeding was an issue there and how was it addressed. We include several important quotes from these interviews in the results and discussion.

[4] 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, because journals may vary in quality, controlling for journal quality would have been a good refinement. Unfortunately, such data were not available. Second, we did not cover other scholarly outputs, such as books and conference papers. Yet, these tend to be less consistent in quality than peer-reviewed journals and thus even more noisy measures of output (Lewison 2001). Finally, the data were self-reported, so we could not make an independent validation because respondents remained anonymous for reasons of confidentiality. Yet, a recent survey on "Changes in the Academic Profession" implemented in Mexico (see Galaz-Fuentes et al. 2009) offers an indirect validation of our variables because some historical questions about research outputs yielded descriptive statistics that are very similar to those of the survey we used.

[5] Although we cannot separate patents from prototypes, figures for the total number of patents produced by Mexican universities from other sources suggest that the overwhelming majority of this output variable refers to prototypes rather than patents.

[6] The system is totally dominated by public universities, and so there are no pay differences for the same academic rank.

[7] Experience in academia is sometimes represented 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; however, we found the squared term was mostly nonsignificant, and its inclusion did not alter the rest of the regression results. Thus, we decided to drop the quadratic term from the analysis and include only the linear term.

4. Analysis and Results

The first hypothesis suggests that noninbreds are relatively more likely to favor the exchange of scholarly information with external sources as opposed to internal sources than inbreds. To test this hypothesis, we developed 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 noninbreds 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 included 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 noninbreds.[8] In deciding these areas, we followed the scheme proposed by ANUIES, the national association of higher education institutions in Mexico. The scientific fields considered in the estimation include natural sciences (what is known in Mexico as "exact sciences": mathematics, chemistry, and physics), social and administration sciences, education and humanities, engineering and technology, health sciences, and agrarian sciences. Institutional and area effects were included in all regressions but were not reported in the tables because of space limitations.

Table 2 presents the results of the estimation. Given that a higher *information exchange practices* score represents more external openness, the findings strongly confirm the argument that inbred faculty collaborate less and exchange relatively 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 noninbred faculty members is significant, with inbreds having roughly a 50% lower external information exchange score compared with noninbreds. This result lends strong support to the validity of the openness hypothesis. These observations were seen as unsurprising to the great majority of the university administrators and managers interviewed. One dean was particularly pointed in his evaluation:

> In this school, inbred professors communicate in more restricted circles .... Professors hired from other universities have broader networks, participating in both national and international networks. Although we should not generalize, it seems to me that inbreds feel more comfortable with internal networks as they provide a safer environment for communication.

Table 2 **Effect of Academic Inbreeding on Information Exchange Practices**

Variable	Relative external openness score
Inbreeding	-0.548^{***}
	(0.200)
Years since first contract	0.008
	(0.009)
Male	0.047
	(0.187)
Participate in collective R&D project	-0.011
	(0.224)
Funding for R&D last three 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

Notes. A linear regression with university and scientific area fixed effects and robust errors is shown. We also performed this estimation using each individual information exchange practice, rather than the average value of the scores, using 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 this table.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Next, we analyzed Hypothesis 2, which suggests that inbreds produce fewer scientific outputs than noninbreds. Estimating the impact of inbreeding on academic output requires a procedure that can handle a dependent variable that is nonnegative and based on counts. Because our error term is overdispersed, we used 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 (see Wooldridge 2001), Y_{ijk} is the scientific output of academic i in institution j and scientific field k, and 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.

[8] For example, it is likely that the Universidad Nacional Autónoma de Mexico, a large and well-known institution, attracts better people for its ranks, both inbreds and noninbreds, 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 institutions, in particular, quality, size, and proportions of inbred and noninbred faculty in each school. Instead, what we are interested in is comparing the output of inbreds and noninbreds within the same institution and field.

Table 3 Relationship Between Inbreeding and Academic Outputs

	Supervision undergrad thesis (1)	*Supervision of master thesis* (2)	*Supervision of Ph.D. thesis* (3)	*Articles in peer-reviewed journals* (4)	*Consultancy (govt. or private)* (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 three 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

Notes. A negative binomial regression with university and scientific area fixed effects and robust errors is shown. Bold represents the result of the explanatory variable for the given model.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

As can be seen in Table 3, academic inbreeding has no effect on teaching outputs (columns (1)–(3)), as no statistically significant differences were found. This does not necessarily mean that inbreeding does not have an effect on the teaching process; however, if it does, it is not seen by the number of theses supervised. However, a statistically significant difference in research production is identified, with inbred faculty generating on average 15% fewer scientific papers than noninbreds (column (4)). Interestingly, the results for scientific productivity contrast with those associated with the outreach mission of the university, which we can proxy through the *number of consultancy contracts*, or the *numbers of prototypes and patents* created. 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 noninbred peers.[9]

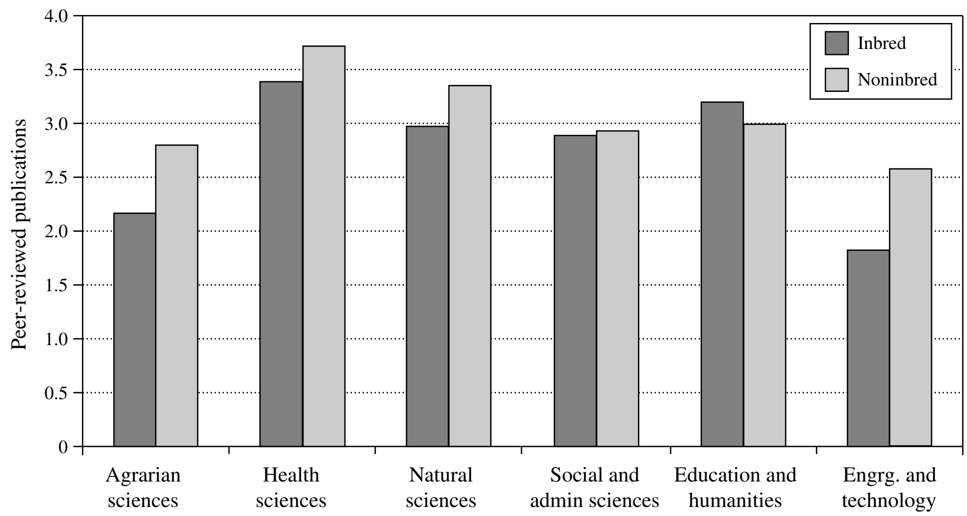
Overall, results confirm the perceived notion in the literature that academic inbreeding practices are detrimental to the production of scientific outputs. As Figure 1 shows, this productivity gap persists across most areas of knowledge, albeit with different intensities. It seems to be especially relevant in the areas of engineering and natural sciences, with noninbreds active in engineering and technology generating close to 45% more publications. The negative effects of inbreeding are also evident across the various institutions. In particular, our estimates (not shown in the article but available from the authors) indicate that, even in more research-oriented universities, academic inbreeding negatively affects scholarly output, 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. However, it does not entirely eliminate the negative outcomes.

These results indicate that inbred faculty tend to favor the internal exchange of information compared with their noninbred peers, and that an inbred faculty produces less scientific outputs. These results validate Hypotheses 1 and 2A. Yet, although openness and scientific output are theoretically related, Hypothesis 2B proposes that openness may indeed be a critical vehicle by which inbreeding conditions scientific productivity. To test this idea, we added the *relative external openness score* as an additional independent variable to our estimations. This allowed us to test how scientific outputs are affected by the relative external–internal orientation in terms of information acquisition and, at the same time, assess to what extent the effects of inbreeding are evident when this additional control is considered.

Table 4 presents the results of this estimation (column (7) repeats column (4) of Table 3 to facilitate comparisons). As can be observed in column (8),

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

Figure 1 **Predicted Values for Faculty Scientific Productivity Over Three Years (1999–2002)**



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

the relative preference for exchanging information with external sources impacts positively the production of articles in peer-reviewed journals. The analysis also reveals that the preference of inbred faculty for exchanging information internally appears to be the critical issue associated with their lower scientific productivity when compared with their noninbred peers. In fact, one can see in column (8) of Table 4 that the *inbreeding* variable becomes nonsignificant when the *relative 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.[10] This result supports our Hypothesis 2B, reinforcing the argument that inbred faculty are less productive because of their navel-gazing practices, the dependence on internal knowledge acquisition. In fact, one department chair we interviewed noted:

> What I observe at this and other Mexican universities is that openness creates a dynamic and competitive process whenever we are considering a research framework.

Although these results seem to support Hypothesis 2B, there is a potential issue of unobserved researcher heterogeneity related to our critical variables. In particular, it is possible that inbreeding is working as a proxy for inherent researcher ability. If this were the case, we would be measuring differences in ability rather than the inbreeding mechanism we wish to test. Although it is impossible to completely rule out this possibility, we decided to explore a different estimation approach to provide additional robustness to our results. To that end, we considered the notion that, because openness appears to be the critical factor by which inbreeding impacts on scientific productivity, one should find that the element of time would have an important influence on the results. In fact, the research network for a freshly minted Ph.D. 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 noninbreds early on in their careers. Yet, if the inbred academic remains confined around the graduate school environment, we would expect to see research productivity becoming progressively worse over time. On the other hand, if inbreeding is measuring inherent ability, the effect would not change over time. Because we know when each of the faculty completed their Ph.D., we can test this idea by interacting inbreeding with the variable *years since first contract*, a measure that is included in our regression analysis. We would expect to find this interaction to be negative. But this should not apply to the *relative external openness* measure because that is contemporary to our output measurement, and thus is the intrinsic result of the socialization process of each faculty over time. As a result, the time factor (assessed also through an interaction effect) should not be significant.

The results of these alternate estimations are also included in Table 4. In column (9) we can see that, as expected, the interaction effect of *inbreeding* becomes highly significant with time, whereas the main effect loses statistical significance. This suggests that the negative effects of inbreeding are accrued over time. *Inbreeding* is no longer significant because

[10] The information exchange orientation does not appear to have an effect on teaching and outreach activities and is only marginally significant in terms of supervision of Ph.D. thesis, which is a combination of teaching and research.

Table 4 Robustness Checks for Inbreeding, Scientific Productivity, and Information Exchange Practices

	Articles in peer-reviewed journals (7)	*Articles in peer-reviewed journals* (8)	*Articles in peer-reviewed journals* (9)	*Articles in peer-reviewed journals* (10)
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 X 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 three 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 X 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

Notes. A negative binomial regression with university and scientific area fixed effects and robust errors is shown. X = interaction. Bold represents the result of the explanatory variable for the given model.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table 5 Relationship Between Inbreeding and Some Key Research and Teaching Variables

	Participates in collective R&D project (11)	*Has funding for R&D last three years* (12)	*Teaches undergraduate students only* (13)	*Teaches graduate students only* (14)	*Average number of students per class* (15)
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	−1,572.7
Observations	413	364	400	295	409

Notes. Regressions with university and scientific area fixed effects and robust errors are shown. Probit regressions are shown in columns (11)–(14). A negative binomial regression is shown in column (15).
$^{**}p < 0.05$; $^{***}p < 0.01$.

it is explained by the *external openness score* as a process variable; in other words, it represents the mechanism explaining why *inbreeding* impacts negatively on the *production of articles in refereed journals* (see Baron and Kenny 1986). In contrast, column (10) shows that the main effect for the *openness score* variable remains significant, whereas the time interaction is not. As expected, the effect of *external openness* is not affected 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 Table 3 provide some early support for this notion. As shown, inbreds are much more active in external "outreach activities," including consulting contracts, as well as in the generation of prototypes and patents. Yet, one might conclude that these activities are related to the individual's pursuit of alternative sources of income, rather than being the results of any institutional practice. To further explore the possibility that inbreds play a particular nonresearch role in universities, we then looked at how inbreeding relates to activities of teaching and research rather than scholarly outputs. To do this, we used a negative binomial regression (discussed earlier) and a probit where $\Pr(Y_{ijk} = 1) = \Phi(x_{ijk}'\beta + \alpha_j + \delta_k)$; the term $Y_{ijk} = 1$ indicates that the faculty member was engaged in the relevant activity, and zero otherwise. The individual controls, as well as the area and institution effects, are the same as those used in previous estimations.

Table 5 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, to teaching activities associated with lower levels of academic learning (e.g., teaching at the undergraduate level). Inbred faculty are 32% more likely to teach undergraduate students only than noninbreds, and 73% less likely to be teaching only graduate students. In addition to being mostly allocated to undergraduate teaching, inbred faculty also have to make a greater effort than noninbreds in terms of teaching engagement. Inbreds have 12% more students per course than noninbreds. This uneven allocation of teaching time is important because teaching activities, in particular, time spent in undergraduate teaching, is thought 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, whereas noninbreds can devote more time and effort to research. This would indicate that academic inbreeding may result partly from institutional practice and perhaps even from strategy. Yet, when we discussed this with university leaders, most showed unawareness or even resistance to the idea that there might be a deliberate strategy. Instead, they refer to an implicit and *subconscious process* driven by the aptitudes and motivations of faculty, such that "inbreds tend to focus on and be concentrated in teaching and management activities" (department chair), whereas "young doctorates hired from outside the university, particularly the ones who did their Ph.D. abroad are only interested in research, with little interest in training of human resources or management activities" (department chair).

As proposed in Hypothesis 4, if a moderate presence of inbred faculty is the result of a strategy that aims at improving the research capabilities of the school, we should see 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 noninbreds. To test these ideas, we explored how the average rate of academic inbreeding for each institution and scientific field conditions the research output of noninbred faculty. For that purpose, we estimated a negative binomial model, similar to the one used in the estimations presented in Table 3, but considering only the subset of faculty that are noninbred. Then, instead of including an individual dummy that signals the inbreeding status of the faculty member, we considered the average level of inbreeding in the field and institution of the focal individual. Finally, because we expected the effect to be nonlinear, we also considered the square of this measure in the regression.

Table 6 presents the results of the estimates. As shown there, the coefficient on the linear term of the inbreeding variable is positive, whereas 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. Estimates suggest that the output benefit for noninbreds 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 noninbreds see a decline in their rate of scientific output. Although the impact in the total output for a university depends on the balance between the lower output associated to the share of inbreds, and the added benefit their presence brings to the output of the remaining noninbreds, the estimates suggest that it is plausible that a small presence of inbred faculty (below 32%, where the benefit to noninbreds is maximized) can lead to a total net benefit to the scientific output of a school.

Table 6 Effect of Academic Inbreeding on the Scientific Output of NonInbred Faculty

Considering only *noninbred faculty*	*Articles in peer-reviewed 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 three 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

Notes. A negative binomial regression with fixed effects and robust errors is shown. Bold represents the result of the explanatory variable for the given model.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

The university leaders we interviewed recognize the importance of limiting the presence of inbred faculty members. Yet, rather than talking about policies to prevent academic inbreeding (only a few referred to some sort of informal agreement to limit it), they highlighted the need to balance stability and organizational identity with organizational innovation and change. One rector stated:

> They [graduate students] assimilate the behaviors of a particular area of knowledge and research group within the university, making them a potential ally for the development of that group ...; a newcomer from another university may not want to join an established research group but rather would wish to form his own.

The same interviewee and several others further noted that a balanced faculty is desirable because both groups bring benefits to the university when their presence is not excessive.

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 all institutions and areas of knowledge. Moreover, results suggest that the detrimental effect of inbreeding in research is centered in the inbred academic's bias toward information exchange inside 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 organizational process. First, we show that mobility strategies are reflected in levels of research productivity, rather than only in access to specific knowledge or research directions, as explored in previous work. Second, we demonstrate that external openness to information exchange is the key mechanism that helps explain such differences. Finally, we also show that the negative impact of inbreeding on scholarly output happens progressively as inbreds fail to keep up with the evolution of scientific knowledge.

The individual results open up a critical question that has 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 implicit institutional practice, such that noninbred faculty mostly focus on research activities and inbred faculty contribute disproportionately more to teaching and outreach activities. In particular, inbreds have higher teaching loads and larger undergraduate classes. Similarly, they are more involved in consultancy contracts with government and private firms. Because 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 inbreeding can have a positive impact on the research output of noninbreds. This effect is significant, and thus it is plausible to consider that it can outweigh the inferior research outputs that inbreds tend to generate. This dimension, coupled with other factors such as information asymmetry for outside faculty applicants, provides a clear rationale for why schools might decide to hire some of their own Ph.D. graduates. The academic leaders in Mexico we interviewed reinforced this idea by stressing the need for a balance between inbreds and noninbreds in the academic staff ratio, recognizing the benefits that both groups bring to the university, as long as one group does not become dominant in relation to another.

The problem, as noted also by university managers and the perceptions of academics, emerges when a careful and limited institutional solution becomes an established recruitment practice and inbreeding rates start to grow. Our findings show that, when inbreds become the dominant group, there are important spillovers affecting noninbreds, who see their productivity declining. This result can be understood if one reflects on the organizational processes that are 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, Cohen and Levinthal 1990) and perhaps even more so for universities, which rely intensely on advanced knowledge (Nowotny et al. 2001). It is through these links that relevant information is sought, filtered, retrieved, and then disseminated within the university and socialized to peers (Allen 1977). As a university hires more inbreds, inward-looking 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 is likely to become less open to acquiring new knowledge or different methodologies or frameworks.

The potential effect can be summarized by the words of Cohen and Levinthal (1990, p. 133): "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 body of organizational knowledge in terms of scope and flexibility (Camerer and Vepsalainen 1988). In extreme situations, it could lead to 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's legitimacy and social utility in jeopardy (Scott 1995).

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 progressively institutionalized, the overall faculty gradually turns inward, and power cliques that maintain the status quo emerge and consolidate. Thus, it is difficult to know just when the pernicious effects of inbreeding become dominant over its potential benefits associated with teaching and outreach. Such a process would help explain how universities and entire national systems can be slowly driven into an inbreeding trap, from which it may be difficult to escape.

If similar processes are at work in knowledge-intensive groups beyond the university, inward-focused information exchange practices are the key to understanding why knowledge deteriorates, and ultimately may harm levels of scientific productivity. To be sure that research productivity reaches its full potential, research managers ought to consider bringing outsiders in on a regular basis to promote openness and facilitate knowledge renewal, thus balancing the typical path-dependent and localized search processes of individual researchers within their groups (Rosenkopf and Nerkar 2001, Singh 2005).

6. Conclusions

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

Overall, our analysis strongly suggests that a small presence of inbreeding can be beneficial to scientific productivity, but widespread inbreeding practices, especially if they reach the levels found in countries such as Spain or Portugal, should be countered and probably prevented. Universities should ensure periodic renewal of their core faculty with professors trained in other institutions and schools. Governments need to provide strong incentives relating job mobility to career progress, and perhaps consider the establishment of limits regarding the presence of inbreds among faculty.

Despite these consistent findings, it is important to remember that this study was developed using data from Mexico. Although Mexico's 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 inbreeding, thus breaking an important part of the negative cycle. Further work looking at intermediate systems, such as in Spain or Portugal, could provide very valuable insights into the generalizability of these findings.

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Appendix. Correlation Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
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 Ph.D. thesis supervised (4)	0.11	0.03	0.41	1							
Number of articles in peer-reviewed 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 three 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
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
Male (14)	0.00	−0.02	0.16	0.04	0.04	0.14	0.10	0.00	0.07	0.00	0.00
Inbreeding (15)	−0.20	0.05	−0.05	0.05	−0.05	0.05	0.16	−0.03	0.09	0.02	−0.08
Agrarian sciences (16)	0.04	−0.03	0.02	0.04	−0.02	0.00	0.10	0.00	0.02	0.02	−0.03
Health sciences (17)	−0.05	−0.03	0.07	0.10	0.08	−0.01	−0.05	0.04	0.03	0.01	−0.04
Natural sciences (18)	0.03	−0.13	−0.20	−0.07	0.08	0.06	−0.16	0.10	0.09	0.04	−0.07
Social sciences (19)	0.11	0.07	0.02	0.05	−0.02	−0.09	0.08	−0.16	−0.12	−0.08	0.05
Humanities sciences (20)	−0.03	0.04	−0.02	−0.02	0.00	−0.03	0.02	−0.03	−0.08	−0.01	−0.03
Engineering (21)	−0.10	0.09	0.17	−0.03	−0.14	0.05	0.10	0.03	0.05	0.02	0.10

	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Average number of students per class (12)	1									
Years since first job in academia (13)	0.00	1								
Male (14)	−0.12	0.07	1							
Inbreeding (15)	0.11	0.08	−0.07	1						
Agrarian sciences (16)	−0.13	−0.03	0.02	−0.04	1					
Health sciences (17)	0.14	0.02	−0.06	0.13	−0.05	1				
Natural sciences (18)	0.04	−0.11	0.04	−0.11	−0.11	−0.28	1			
Social sciences (19)	−0.06	0.07	−0.11	0.01	−0.07	−0.17	−0.37	1		
Humanities sciences (20)	0.12	0.03	−0.14	0.08	−0.05	−0.12	−0.26	−0.16	1	
Engineering (21)	−0.15	0.04	0.21	−0.02	−0.07	−0.18	−0.40	−0.24	−0.17	1

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