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Holding a post-doctoral position before becoming a faculty member: does it bring benefits for the scholarly enterprise?

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Abstract This article examines the effects that performing a post-doc early in the academic career have for the current scholarly practices of faculty members. Results show that performing a post-doc early in the academic career impacts positively the recent research output of academics, although not affecting the other faculty member's scholarly activities, namely teaching. The results also show that academics that did a post-doc engage in more regular information exchange dynamics with international peers than their colleagues that did not. This is particularly evident for the younger generations of scholars and for those who spent the post-doctoral period abroad. It is concluded that the post-doctoral period not only fosters a greater production of scientific outputs later in the academic career, but also leads to a greater integration into international scholarly communities. These benefits potentiate former post-docs to become key players in any scientific or higher education system.

Keywords Post-doctoral period · Scholarly production · Information exchange · Internationalization of academic activities · Locality

Introduction

In recent decades, doing a post-doctoral period has been increasingly common after concluding doctoral studies. This commonality results from an increasing unbalance between the number of available tenured and tenure-track jobs in higher education and the number of doctorates. For example, in the US, while the number of academic jobs has grown by 0.8% the number of post-docs has grown by 3% in the last 10 years (Dawson 2007). Some authors often underline the importance of post-docs and urge for public

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policies that can better integrate them into academe (Enders and Weert 2004; Huisman et al. 2002; Musselin 2004). Increasingly, post-docs are a critical element of the scientific community and their contribution to the advancement of knowledge is steadily growing more significant (Enders 2005).

For a recent doctorate, a post-doc can be understood as further investment in knowledge acquirement and diffusion while dealing with increasingly constrained academic labor markets (Stephan and Ma 2005). One perceived form into which this investment can be understood is as a means to increase the number and quality of scientific publications. Consequently, this increases one's chances of getting an academic job (Levin and Stephan 2001). In this sense, the postdoctoral period can be often described as a 'waiting position' for a permanent position (Recotillet 2007) or as a probation period for a future position (Stephan and Ma 2005).

However, despite the fact that the role of the post-docs has been underlined as important mainly for the academic research enterprise, there has not been a clear indication of the real benefits that the post-doctoral period brings to faculty members and, ultimately, to the scientific base of a country. This is surprising in the sense that substantial sums of money are provided, mostly by public sources, to sponsor post-doc fellowships. For example, in Sweden a post-doc fellow usually costs between 20,000 and 40,000 Euros per year (Melin 2005) and in Portugal the 302 ongoing post-doctoral fellowships in 2005 cost more than 18 million Euros.[1] In this sense, the opportunity cost of doing a post-doc is an investment not only made by the recent doctorate (in terms of dedication, effort, and life and career instability; see Melin 2005 or Musselin 2004), but also by the sponsor (mostly in financial terms), which in the great majority of the cases is the state (e.g., Geva-May 2001).

The aim of this article is to fill this gap in the literature by looking at the benefits that doing a post-doc brings to the scholarly dynamics of faculty members that did them at the start of their academic careers. In order to do this, this article analyzes the importance that performing a post-doc early in the academic career has for recent faculty scholarly achievement. Moreover, it also analyzes the impact that doing a post-doc early in the academic career has in shaping current faculty's engagement in international academic and scientific networks. Since it is acknowledged that the post-doctoral period, in a similar way to the doctoral phase, is a time of socialization and intellectual growth, we take into account the locality where the post-doc was performed in the analysis.

Data and methods

The data used in this research is based on a survey conducted to analyze the evolution of the academic profession and the effects of public policy in higher education institutions within Mexico. The dataset comes from a survey sponsored by the Mexican *Consejo Nacional de Ciencia y Tecnologia* (CONACYT), which was designed and implemented by researchers from the *Universidad Autónoma Metropolitana* from Mexico (see Kuri et al. 2004). The survey provides information between 1999 and 2002 on academics' demographics, career mobility, work experience, work conditions, work satisfaction levels,

[1] Source: Fundação para a Ciência e Tecnologia, departamento de Formação dos Recursos Humanos em Ciência e Tecnologia, 2007 links: http://alfa.fct.mctes.pt/images/stat/B52.gif; http://alfa.fct.mctes.pt/images/stat/B42.gif (accessed: 26th of February 2008).

academic socialization, and family and social environment. This information is available for all scientific areas and institutions in the Mexican higher education system. The survey employs a representative sample of academics of the Mexican higher education system, based on the total faculty that every Mexican higher education institution reported to the *Asociación Nacional de Universidades e Instituciones de Educación Superior* (ANUIES). In total, 5,000 questionnaires were sent to faculty members in 82 higher education institutions; 3,861 were returned, representing a response rate of 79%.[2]

Taking into account the purpose of this article, the dataset required some filtering. This consisted in considering only faculty members holding a doctoral degree as the matching sample. Holding a doctoral degree is the essential first step of a scientific and academic career, because it represents an embedment of academic practices as well as an "apprenticeship for research" (Recotillet 2007, p. 477). Also, considering doctoral holders only is an important requirement as the analysis will focus on scholarly achievement, and part of this scholarly achievement is defined by scientific publications and supervision of doctoral theses. Finally, it makes sense to compare between doctoral holders and post-doctoral holders because the post-doctoral period is only possible after the completion of a doctorate (Musselin 2004). After the filtering process, the dataset consisted of 492 cases, which referred to all academics in the original dataset that hold a doctoral degree, of which 21% were academics who did a post-doc. The proportion of faculty that were former post-docs vary by higher education institution (the one with the highest proportion has 54% of their faculty as former post-docs).

This article focuses on two main questions, each reflecting a core outcome of faculty characteristics and activities. One outcome refers to the information exchange dynamics with international peers. The survey asked about six types of information exchange practices: (1) information exchange about research and teaching activities, (2) information exchange about innovative subjects and articles, (3) information exchange about equipment and research techniques, (4) information exchange about financial sources for research, (5) information exchange about publishing and diffusion of research results, and (6) information exchange about job opportunities. For each category, information exchange with international colleagues was recoded as an ordinal variable, in order to indicate whether the information exchange with international colleagues was 'none', 'rare', 'occasional' or 'frequent' (coded from 1 to 4).

The other measured outcome refers to the faculty members' scholarly achievement. This consists of outputs representing the functions of teaching, research and outreach that are at the core of academic activity in higher education institutions. The variables that are associated with teaching output are the number of undergraduate, master and doctoral theses supervised by faculty members.[3] Research output is measured through two types of publications: books and articles published in peer-reviewed journals. The use of two types of publication to characterize research output is explained by the fact that not all scientific fields privilege the same means of publishing research results (Levin and Stephan 2001). This also permits the performance of an analysis by each scientific field. For the assessment of outreach activities, the number of prototypes and patents is used.[4]

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

[3] Although the supervision of doctoral thesis is placed under teaching, the performance of doctoral work has also a very strong component of research, and therefore represents a mix between the two activities.

[4] This variable mostly reflects prototypes rather than patents which are almost inexistent in the Mexican higher education system—from 1999 to 2002 top research institutions in Mexico submitted a total of only 36 patents during the period (CONACYT 2004).

The data regarding these variables is obtained directly from the survey where academics are asked for their scholarly output between the year 1999 and 2002. The chosen time frame is critical because focusing on the relatively recent scholarly production instead of an academic's career scholarly production avoids possible biases arising from the fact that the post-doctoral period is mostly oriented towards research (including increasing the number of publications) to the detriment of teaching (see Stephan and Ma 2005). In other words, the academics that hold a post-doctoral period would most likely have a greater career scientific output than the academics that did not, simply because the post-doctoral period has an emphasis on publishing research results.[5]

The analysis will focus mainly on the explanatory variable 'Did post-doc early in the career'. In the survey, the concept of post-doc refers to post-doc positions taken after the conclusion of the doctorate. This variable assumes a binary character where a faculty member that had been through a post-doctoral period will be coded as 1, while the ones that did not will be the baseline. However, because there is information regarding the locality where the post-doc was performed, further analysis is conducted using three explanatory variables referring to three locations: post-doctoral spells based at an institution outside Mexico (i.e., abroad), post-doctoral spells based at *Universidad Nacional Autónoma de Mexico* (UNAM), and post-doctoral spells based at other Mexican universities except UNAM.

The separation of the analysis referring to the spell of the post-doctoral periods spent within the Mexican higher education system—between UNAM and other Mexican universities—is explained by the need to understand the impact of performing the post-doctoral spell at a national university, characterized by being globally connected, research intensive and internationally renowned. UNAM is the straightforward choice for Mexico since it is the only Mexican university constantly present in all international rankings.[6] Unfortunately, for the scholars that did the post-doc abroad, it is not possible to perform the analysis by university or country, since it was not asked in the survey. Although it would be interesting to perceive the impact of the location of the post-doc abroad for the current scholarly behavior and production of academics—namely if it was spent at global research universities or not, or in countries with a developed scientific base or not—that does not impede on achieving the objectives of this article.

In addition to the explanatory variables, the analysis requires an important set of control variables. The aim is to be certain that when the impact of holding a post-doc is estimated, its effect is not attributed to other characteristics that are likely to be correlated both with information exchange practices and scholarly achievement. The control variables include characteristics that are intrinsic to the faculty member such as age (Gonzalez-Brambila and Veloso 2007), gender (e.g., Fox and Stephan 2001) or nationality (e.g., Carayol and Matt 2006), and others associated with the organizational context that constrain faculty behavior, such as teaching levels, average number of students in class, research funding sources, holding a job outside academia, and scientific fields (see Bonaccorsi and Daraio 2003; Carayol and Matt 2006). The descriptive statistics of the dependent and independent variables are presented in Table 1.

[5] Also, there is no information on career scientific output because the survey did not inquire about it.

[6] See: *Clasificación de universidades de México* (i.e., ranking of Mexican universities): http://es.wikipedia.org/wiki/Clasificaci%C3%B3n_acad%C3%A9mica_de_universidades_de_M%C3%A9xico (Accessed on the 5th February 2009).

Table 1 Summary statistics for the dependent and independent variables

Type of variable	Variable	Obs	Mean	SD	Min	Max
Dependent variable—scholarly achievement	Supervision undergraduate thesis	492	2.10	2.18	0	9
	Supervision master thesis	492	1.40	1.51	0	6
	Supervision PhD thesis	492	0.60	1.00	0	4
	Articles	492	3.12	2.54	0	16
	Books	492	1.09	1.80	0	9
	Prototypes and patents	492	0.12	0.50	0	6
Dependent variable—information exchange international peers	I.e. research and teaching activities	477	2.13	1.05	1	4
	I.e. innovative subjects and articles	477	2.16	1.12	1	4
	I.e. equipment and research techniques	477	1.96	1.06	1	4
	I.e. financial sources for research	477	1.84	1.01	1	4
	I.e. publishing and diffusion of research results	477	2.00	1.07	1	4
	I.e. job opportunities	477	1.66	0.93	1	4
Independent variables	Did post-doc early in the career	492	0.21	0.41	0	1
	Did post-doc abroad early in the career	492	0.16	0.37	0	1
	Did post-doc at UNAM early in the career	492	0.02	0.14	0	1
	Did post-doc in other Mexican university early in the career	492	0.03	0.16	0	1
	Mexican nationality	492	0.88	0.33	0	1
	Age	492	48.17	8.87	31	80
	Male	492	0.67	0.47	0	1
	Teach undergraduate only	492	0.05	0.22	0	1
	Teach graduate only	492	0.23	0.42	0	1
	Teach all (both undergraduate and graduate)	492	0.72	0.45	0	1
	Average student per course	492	22.36	12.01	0	60
	R&D funding sources: no sources/ no fund	437	0.20	0.40	0	1
	R&D funding sources: internal	437	0.18	0.38	0	1
	R&D funding sources: external	437	0.62	0.48	0	1
	Other job outside academia	492	0.39	0.49	0	1
	Agrarian sciences	492	0.03	0.17	0	1
	Health sciences	492	0.10	0.30	0	1
	Exact sciences	492	0.32	0.47	0	1
	Social sciences	492	0.21	0.40	0	1
	Humanities	492	0.11	0.31	0	1
	Engineering	492	0.24	0.43	0	1
	hei3	492	0.03	0.17	0	1
	hei4	492	0.01	0.11	0	1
	hei5	492	0.02	0.15	0	1

Table 1 continued

Type of variable	Variable	Obs	Mean	SD	Min	Max
	hei19	492	0.03	0.16	0	1
	hei21	492	0.07	0.25	0	1
	hei22	492	0.03	0.16	0	1
	hei23	492	0.18	0.39	0	1
	hei27	492	0.30	0.46	0	1
	hei28	492	0.01	0.12	0	1
	hei34	492	0.01	0.11	0	1
	hei42	492	0.03	0.16	0	1
	hei43	492	0.02	0.13	0	1
	hei46	492	0.03	0.18	0	1
	hei51	492	0.05	0.22	0	1
	hei56	492	0.03	0.18	0	1
	hei63	492	0.03	0.17	0	1
	hei65	492	0.05	0.22	0	1
	hei66	492	0.02	0.13	0	1
	hei68	492	0.02	0.13	0	1
	hei75	492	0.01	0.12	0	1
	hei84	492	0.02	0.13	0	1

Note: The names of the higher education institutions are coded by numbers in order to maintain their confidentiality; *hei* means higher education institutions; Correlation table in the appendix (Table 12)

The estimation of the impact of a faculty member having been through a post-doctoral period on international information exchange relies on an ordered probit regression model for each of the six information exchange categories (see Winship and Mare 1984). That is:

$$Y_{ijk} = \beta X_{ijk} + \alpha_j + \delta_k$$

where the dependent variable Y_{ijk} represents the international information exchange intensity for each of the information exchange categories for faculty member i at higher education institution j for scientific area k. The independent variables (X_{ijk}) include a dummy variable indicating if the faculty member undertook a post-doctoral period or not (0 for not taking a post-doc and 1 for taking a post-doc). The independent variables also include all the above mentioned controls. Additionally, the equation includes fixed effects for institution (α_j) and scientific field (δ_k).

These fixed effects are relevant since they control for the characteristics of different institutions (e.g., these can be private or public; larger or smaller; broader or narrower in their scholarly focus; with greater or lesser reputation), and also for the heterogeneity of the scientific fields and the related propensity for information exchange with international peers, as well as for scholarly achievement. The introduction of fixed effects in the model controls for possible biases and reduces the occurrence of misleading results. For example, if institutional fixed effects were not introduced in the model, results concerning scholarly achievement could be more driven by unobserved effects resulting from institutional differences than by differences between academics who undertook a post-doctoral position and those who did not.

The outcome variable (Y_{ijk}) for the information exchange categories represent a latent continuous variable that underlies the ordered form of the observed variable γ_{ijk} where,

$$\begin{aligned}
\gamma_{ijk} &= 0 \quad \text{if } Y_{ijk} \leq \tau_0 \\
\gamma_{ijk} &= 1 \quad \text{if } \tau_0 < Y_{ijk} \leq \tau_1 \\
\gamma_{ijk} &= 2 \quad \text{if } \tau_1 < Y_{ijk} \leq \tau_2 \\
\gamma_{ijk} &= 3 \quad \text{if } \tau_2 < Y_{ijk} \leq \tau_3
\end{aligned}$$

The parameters τ_0,τ_1,τ_2, and τ_3 provide information on the distribution of the ordinal variable γ_{ijk} and are estimated at the same time with the β parameters (Ouimet et al. 2007).

To estimate the impact of doing a post-doc on the academics' scholarly achievement, a regression that deals with a counting variable and that is non-negative is necessary. In this case, there is always the possibility of using a Poisson regression. The Poisson regression restricts the variance of the dependent variable to be equal to the mean. However, an over-dispersion is observed for all variables. Therefore, we use a negative binomial regression that better fits the characteristics of the data (see Wooldridge 2001), and base our analytical model for scholarly achievement on:

$$P\left(Y_{ijk} = y_{ijk}\right) = F\left(x_{ijk}\prime\beta + \alpha_j + \delta_k\right)$$

where F is the negative binomial distribution, Y_{ijk} is the scholarly achievement of faculty member i in institution j and scientific field k. X_{ijk} represent the independent variables that vary across faculty, scientific field and institution; α_j are the institutional effects, δ_k are the scientific field effects.

Post-docs turned academics in the Mexican higher education system: promoters of international connectedness

Table 2 shows the estimates of information exchange between Mexican academics and international peers concerning several categories. The results show that the effects of doing a post-doc earlier in the academic career are positive and significant for all the information exchange categories. This implies that the post-doctoral period helps to promote the contact and collaboration with peers from other countries, thus facilitating the integration of national academics into the international scientific community.

In the analysis, it is relevant to note the significant and positive effects of funding research activities to foster information exchange with international peers. The most important funding source to foster this information exchange activity is external to the university (can be either private or public, or both). This result reinforces previous findings that imply that external sourced funding is an important factor to stimulate interaction and collaboration in academia, notwithstanding that this funding comes from private (Harman 1999) or public sources (Horta 2009 forthcoming). Funding for research projects from internal sources (i.e., own funds from the university) also have a positive effect on information exchange dynamics with international colleagues, suggesting that university level policies towards internationalization involving greater levels of interaction on academic matters with international peers can be fostered if institutional funding is available.

The fact that funding helps to promote a greater interaction among Mexican scholars and colleagues based at international institutions is not surprising. If there are resources available from the start then it is easier to foment collaboration among peers especially when it is known that there are early-stage costs to any collaboration or relationship

Table 2 Ordered probit regression results for the information exchange dynamics

	Research and teaching activities	Innovative subjects and articles	Equipment and research techniques	Financial sources for research	Publish and diffusion of research results	Job opportunities
Did post-doc early in the career	0.324** (0.15)	0.440*** (0.15)	0.464*** (0.14)	0.314** (0.14)	0.359*** (0.14)	0.402*** (0.15)
Mexican nationality	−0.0489 (0.17)	−0.172 (0.17)	−0.0293 (0.17)	−0.148 (0.18)	−0.0723 (0.17)	0.133 (0.19)
Age	0.00490 (0.0071)	−0.0105 (0.0072)	0.000053 (0.0070)0	−0.0155** (0.0072)	−0.0143** (0.0069)	−0.00659 (0.0074)
Male	−0.0670 (0.12)	−0.0885(0.13)	−0.185 (0.13)	0.115 (0.13)	0.109 (0.13)	0.00355 (0.14)
Teach graduate only	0.121 (0.28)	0.156 (0.24)	0.0626 (0.27)	0.176 (0.29)	0.165 (0.25)	0.106 (0.35)
Teach undergraduate only	−0.245* (0.15)	−0.253* (0.15)	−0.0965 (0.15)	−0.257* (0.15)	−0.214 (0.15)	−0.379** (0.16)
Average student per course	−0.000798 (0.0055)	−0.00701 (0.0053)	−0.00256 (0.0057)	−0.00293 (0.0057)	−0.000997 (0.0055)	−0.00995* (0.0056)
R&D funding sources: internal	0.264 (0.19)	0.385* (0.20)	0.331* (0.20)	0.356* (0.20)	0.355* (0.20)	0.384* (0.22)
R&D funding sources: external	0.504*** (0.16)	0.651*** (0.18)	0.446*** (0.16)	0.576*** (0.17)	0.565*** (0.16)	0.442** (0.19)
Other job outside academia	0.223* (0.11)	0.281** (0.12)	0.389*** (0.12)	0.286** (0.12)	0.230** (0.12)	0.0393 (0.13)
Science field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Institutional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Wald test	59.16***	105.72***	92.66***	4466.79***	86.26***	5631.97***
Observations	423	423	423	423	423	423

Note: Standard errors are in parentheses. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05 and 0.10 levels, respectively

(Boissevain 1974). Also, collaboration among scholars is a critical pillar of the scientific endeavor. In spite of cultural, social, and behavioral differences between scientific fields, science has always kept a communal nature (see Babchuk et al. 1999). In this framework, social capital defined as consisting of interpersonal relationships with embedded resources is a decisive factor in understanding knowledge creation (Nahapiet and Ghoshal 1998). Its importance for the scientific endeavor derives from enhancing information exchange processes among scientists and opening access to further network resources (Nahapiet and Ghoshal 1998). Although, our data does not permit the analysis that may determine the academic's positioning, status or prestige within international scholarly networks (these factors alongside with the strength of ties among scientists affect the accessibility to resources and network dynamics: see Podolny and Page 1998; Burt 1992), the information exchange data allows us to analyze the academic's level of involvement in them.

In other words, the social capital within international networks of academics that were former post-docs and academics that were not can be analyzed through the intensity of information exchanged with colleagues based abroad. The intensity of information exchange serves as a relatively good proxy of the level of engagement, commitment, and integration (i.e., level of social capital) with peers at international networks (see Haan 1997). In this context, it is important to note that the formation of relatively stable networks require frequent information exchange dynamics in order to transform collaborative but 'isolated pairs or triads' into research groups, even when these do not share the same geographical location (Haan 1997). The results show that the likelihood of academics who have been former post-docs engaging in occasional and frequent information exchange with international peers—for all information exchange categories—is greater than the likelihood of those who have not undertaken a post-doctoral position (Table 3). On average, the former engage in 4% more frequent information exchange with international peers than the latter. The same holds true for occasional exchange of information (3% more on average). Also, faculty members who have never held a post-doctoral position are more likely not to engage at all in any information exchange dynamic with international peers.

These results suggest that the likelihood of academics with a post-doc integrating into stable international scientific networks is greater than their counterparts without a post-doc. It is important to note also that the social capital of the former in international networks tends to be greater than that of the latter. This emphasizes the importance of the post-doctoral period in facilitating the integration of the national academic core into international teaching and research groups, something that is critical in the scientific sphere (Glanzel 2001; Glanzel et al. 1999).

Table 3 Difference of information exchange intensity with international peers between academics that held a post-doc and academics who did not hold a post-doc position

	None	Rare	Occasional	Frequent
I.e. research and teaching activities	−0.05	−0.01	0.03	0.03
I.e. innovative subjects and articles	−0.07	−0.01	0.03	0.05
I.e. equipment and research techniques	−0.09	0.00	0.04	0.05
I.e. financial sources for research	−0.07	0.02	0.03	0.03
I.e. publishing and diffusion of research results	−0.07	0.00	0.03	0.04
I.e. job opportunities	−0.09	0.03	0.03	0.03

Note: The table results show a direct algebraic estimation between the marginal effects of each 'threshold' parameter of the variable 'Did post-doc early in the career' divided by the mean of each information exchange category

Although the magnitude of the effects above seems to be low, their significance is considerable if we take some considerations into account. The first one is that the integration and active participation in scientific networks is deemed to minimize the detrimental effects deriving from a lack of critical mass to achieve better quality of research results (e.g., Chuang et al. 2007). The other is that the buildup of the academic and scientific base in countries that are quickly developing their scientific systems, but with a still reduced scientific base, such as Mexico, greatly depends upon the integration of the national academic community into international networks (Horta and Veloso 2007; Okubo et al. 1998). Based on the results above, it is feasible that faculty members with a post-doc can be decisive in fostering, or at least, maintaining this integration. The fact that individuals without a post-doc position are 7% more likely not to exchange any type of academic information with international colleagues when compared with colleagues who did a post-doc supports this argument.

Since the post-doc is a relatively recent phenomenon in higher education, with its numbers increasing over recent decades, and there is an ever greater reliance on international knowledge flows, an analysis that focuses on a younger cohort of scholars is relevant. It is possible that the impact of performing a post-doctoral period on international network involvement is bound to be different for the younger scholars that ended the post-doctoral period a few years ago before starting their academic careers when compared with the colleagues from the same cohort who did not. In this context, we did the same analysis as above for the scholars whose age group comprised the lower 25% percentile of the sample population. The group under analysis is aged between 31 and 42 years old, and although we do not have information about the length of their academic career, it is reasonable to assume that it started within the last 15 years.

Similarly to the results of the previous analysis, performing a post-doc makes scholars engage in more information exchange—for all information exchange categories—with their international colleagues.[7] However, the impact of performing a post-doc early in the career on the intensity of information exchange with international colleagues is much stronger for this age cohort than it is for the whole of the sample (Table 4).

The results indicate that the likelihood of young academics who have been through a post-doctoral position to engage in frequent information exchange with international peers is on average 10% more intense than the one engaged by young scholars who have not

Table 4 Difference of information exchange intensity with international peers between academics that held a post-doc and academics who did not hold a post-doc position, aged between 31 and 42 years old

	None	Rare	Occasional	Frequent
I.e. research and teaching activities	−0.10	−0.01	0.06	0.05
I.e. innovative subjects and articles	−0.16	−0.03	0.06	0.13
I.e. equipment and research techniques	−0.20	−0.01	0.09	0.12
I.e. financial sources for research	−0.19	0.00	0.07	0.12
I.e. publishing and diffusion of research results	−0.15	−0.03	0.06	0.11
I.e. job opportunities	−0.29	0.11	0.13	0.05

Note: The table results show a direct algebraic estimation between the marginal effects of each 'threshold' parameter of the variable 'Did post-doc early in the career' divided by the mean of each information exchange category

[7] See Table 13 in the appendix.

undertaken a post-doctoral position. The former are also more engaged in occasional information exchanges with international scholars than the latter (8% more). Perhaps, more importantly, the latter group of young scholars is 18% more likely to have never exchanged information with international peers in the course of their recent academic activities in comparison with the young scholars who did perform a post-doc.

These results show that engaging in a post-doc at the beginning of the academic career may help open-up the academic system to international information exchange and collaboration. The results also highlight that performing a post-doc in the last decade or so (as in the case of the young cohort of scholars) triggers a greater exchange of academic related information with international peers. This may indicate that either the post-doc is a position that enhances greater integration into international networks, or that the results for the younger cohort reflect the drive towards more internationalized—if not globalized—institutions and academic activities (Horta 2009 forthcoming), or both. Either way, the role of these academics that hold a post-doc early in their careers in today's academia seems to be vital. These faculty members are, or have the potential to be, privileged information gatekeepers between the national and international scientific and scholarly communities due to their more frequent international information exchange dynamics (see Kademani et al. 2002). These dynamics may create optimal conditions for a faster consolidation of the national scientific base within the international scientific community, something that countries with a developing scientific base continuously struggle to achieve (see Horta and Veloso 2007).

However, if the effects of performing a post-doc are recognized as positive in fostering a greater involvement of those academics who did them in international scholarly networks, it is also important to realize that the experience of performing a post-doc is not homogenous (Recotillet 2007). If the experience of doing a post-doc is not homogenous, it is plausible to assume that the locality where the post-doc was performed is deemed to alter the recent behavior of academics in terms of international information exchange dynamics. Although most post-doctoral spells are usually characterized for being a period of mobility, learning, and further integration into the scientific and academic career (Enders and Weert 2004; Musselin 2004), not all experiences are the same, or immediately positive or beneficial (see Melin 2005). In this sense, and based on the importance of early academic socialization in molding future academic behaviors, the impact of an academic holding a post-doc on information exchange dynamics with international peers was performed taking the locality where the post-doc was performed into account.

Tables 5 and 6 show the effects that performing the post-doc in three different locations have on the recent international information exchange dynamics of scholars working in Mexican universities. Table 5 reports the results for the whole sample while Table 6 reports the results for the group of scholars with the age comprised between 31 and 42 years old. The results of both tables stress the importance of spending the post-doctoral spell abroad in order to promote greater information exchange with international peers. This result meets the conclusions drawn by Melin (2004) that performing a post-doc abroad brings positive long-term effects that last well beyond the termination of the post-doctoral period. The importance of performing a post-doc abroad on what concerns establishing a greater dynamic of information exchange with international peers is also highlighted by the fact that when the analysis encompasses the younger cohort of scholars alone, the positive effects of performing a post-doc at UNAM disappear. The results demonstrate that only the younger scholars who performed the post-doc abroad are able to interact more with international scholars, while performing it at even a prominent Mexican university like UNAM may not be enough to make them more connected with the international scholarly

Table 5 Ordered probit regression results for the information exchange dynamics and its relationship with the locality where the post-doctoral period was performed

	Research and teaching activities	Innovative subjects and articles	Equipment and research techniques	Financial sources for research	Publish and diffusion of research results	Job opportunities
Did post-doc abroad early in the career	0.352** (0.16)	0.435*** (0.17)	0.431*** (0.15)	0.262 (0.16)	0.421*** (0.15)	0.496*** (0.16)
Did post-doc in UNAM early in the career	0.394 (0.36)	0.741* (0.39)	0.895*** (0.31)	0.746** (0.30)	0.478* (0.28)	0.444 (0.30)
Did post-doc in other Mexican University early in the career	−0.113 (0.26)	0.120 (0.22)	0.184 (0.44)	0.286 (0.27)	−0.502 (0.34)	−0.890** (0.39)
Mexican nationality	−0.052 (0.17)	−0.168 (0.17)	−0.023 (0.17)	−0.140 (0.18)	−0.084 (0.17)	0.129 (0.19)
Age	0.005 (0.007)	−0.010 (0.007)	−0.001 (0.007)	−0.015** (0.007)	−0.014** (0.007)	−0.007 (0.008)
Male	−0.065 (0.12)	−0.088 (0.13)	−0.177 (0.13)	0.109 (0.14)	0.110 (0.13)	0.0001 (0.14)
Teach graduate only	0.110 (0.28)	0.140 (0.23)	0.041 (0.27)	0.156 (0.28)	0.139 (0.26)	0.075 (0.35)
Teach undergraduate only	−0.251* (0.15)	−0.263* (0.15)	−0.103 (0.15)	−0.273* (0.15)	−0.229 (0.15)	−0.405** (0.16)
Average student per course	−0.001 (0.006)	−0.007 (0.006)	−0.003 (0.006)	−0.003 (0.006)	−0.002 (0.006)	−0.012** (0.006)
R&D funding sources: internal	0.280 (0.19)	0.400* (0.20)	0.341* (0.20)	0.362* (0.21)	0.393* (0.20)	0.428* (0.22)
R&D funding sources: external	0.514*** (0.17)	0.654*** (0.18)	0.453*** (0.16)	0.569*** (0.17)	0.585*** (0.17)	0.474**(0.19)
Other job outside academia	0.233** (0.12)	0.289** (0.12)	0.400*** (0.12)	0.280** (0.12)	0.249** (0.11)	0.056 (0.13)
Science field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Institutional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Wald test	58.67***	113.61***	95.58***	100.82***	90.70***	82.11***
Observations	423	423	423	423	423	423

Note: Standard errors are in parentheses. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05 and 0.10 levels, respectively

Table 6 Ordered probit regression results for the information exchange dynamics and its relationship with the locality where the post-doctoral period was performed, regarding scholars aged between 31 and 42 years old

	Research and teaching activities	Innovative subjects and articles	Equipment and research techniques	Financial sources for research	Publish and diffusion of research results	Job opportunities
Did post-doc abroad early in the career	0.813** (0.36)	1.366*** (0.43)	1.436*** (0.36)	1.342*** (0.37)	1.409*** (0.34)	1.982*** (0.36)
Did post-doc in UNAM early in the career	−0.115 (0.64)	0.147 (0.65)	0.232 (0.54)	0.722 (0.71)	0.345 (0.69)	0.517 (0.64)
Did post-doc in other Mexican University early in the career	0.009 (0.64)	0.466 (0.62)	0.908 (0.57)	−0.408 (0.65)	−1.623*** (0.61)	−1.098 (0.70)
Mexican nationality	−0.668* (0.40)	−0.837** (0.40)	−0.321 (0.42)	−0.379 (0.36)	−0.488 (0.30)	−0.286 (0.42)
Age	−0.031 (0.05)	0.021 (0.05)	0.025 (0.05)	0.020 (0.05)	0.034 (0.05)	0.032 (0.05)
Male	−0.497 (0.31)	−0.288 (0.34)	−0.684** (0.32)	−0.074 (0.34)	0.111 (0.36)	−0.596 (0.38)
Teach graduate only	−0.235 (0.36)	0.433 (0.39)	0.403 (0.43)	0.625 (0.40)	0.547 (0.43)	0.158 (0.47)
Teach undergraduate only	−0.366 (0.35)	−0.013 (0.37)	0.274 (0.36)	−0.274 (0.37)	−0.168 (0.33)	−0.509 (0.38)
Average student per course	0.001 (0.012)	0.005 (0.012)	0.0002 (0.013)	0.008 (0.012)	0.022* (0.012)	0.005 (0.012)
R&D funding sources: internal	0.382 (0.47)	0.238 (0.52)	0.804* (0.46)	0.413 (0.50)	−0.431 (0.44)	−0.465 (0.49)
R&D funding sources: external	0.594 (0.41)	0.640 (0.47)	1.112** (0.44)	0.941** (0.41)	0.604* (0.36)	0.449 (0.43)
Other job outside academia	0.545* (0.29)	0.877** (0.37)	0.966*** (0.34)	1.148*** (0.33)	0.618** (0.30)	0.739** (0.36)
Science field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Institutional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Wald test	7682.17***	4999.59***	8645.58***	12101.50***	5740.96***	12400.19***
Observations	117	117	117	117	117	117

Note: Standard errors are in parentheses. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05 and 0.10 levels, respectively

community in comparison with the scholars that have not undertaken a post-doctoral spell at all. This implies that mobility out of the home country plays an important role in securing a greater connectedness with colleagues based at international institutions, in particular, for the younger generation of scholars.

Although the data does not provide information on the whereabouts of the post-doctoral period abroad, it is known that most of the Mexican post-docs perform their post-doctoral period in the US or in Europe.[8] In this sense, one can argue that performing a post-doctoral period in an institution based in a country with a strong scientific system is critical for assuring long-term benefits in terms of international contacts and participation in global scientific and teaching networks. This argument is reinforced by results showing that undertaking the post-doc in a regular Mexican university can be even detrimental in promoting contacts with scholars based at international institutions. It is shown that scholars that did the post-doc in Mexican universities other than UNAM have lower information exchange dynamics with international peers concerning job opportunities for the whole sample and in the publication and diffusion of research results for the younger cohort of scholars, when compared with their colleagues that did not do a post-doc. The deficient research resources and graduate education conditions which characterize most Mexican universities (see Padilla 2008) may explain such results. The low mobility of academics in Mexico and high rates of academic inbreeding (Padilla 2008), which is known to favor internal information exchange at the detriment of information exchange with the outside of the university (Horta 2007), may offer a complementary explanation. If the post-doctoral socialization happens under these circumstances, it is reasonable to expect that little international involvement is achieved at that time, and therefore, the future benefits in terms of integration in international networks are the same as the ones found for faculty members without a post-doc.

The contribution of former post-docs to the Mexican knowledge base

The importance of doing a post-doctoral period early in the academic career for a country's scientific system does not resume itself only to information exchange practices. The results from Table 7 show that the effects of holding a post-doctoral position, particularly impact the research function of the university, including both the production of articles in peer-review journals, and the supervision of doctoral theses (which have a strong component of research). Academics that held a post-doctoral position earlier in their career supervise 18% more doctoral theses and produce 24% more articles in refereed journals than their academic counterparts who did not.[9] Holding a post-doctoral period earlier in the academic career does not impact the outreach function of the university (e.g., prototypes and patents) or more teaching-oriented outputs such as the supervision of undergraduate and master theses. The results concerning the teaching and outreach functions of the university emphasize the role of holding a post-doctoral period earlier in the career for the scholarly achievement associated with the research function of the university. This is an expected result because of the research-focused socialization of the post-doc period itself (Stephan and Ma 2005) and the known positive associations between publishing early in the

[8] See http://www.nsf.gov/statistics/nsf00318/c3s4.htm#mexmobil (Accessed on the 6th February 2009).

[9] The percentages were calculated dividing the marginal effect of the variable 'Did post-doc earlier in the career' by the mean of the scholarly output; In the case of articles: 0.75/3.12 = 24%. See Table 14 in the appendix.

Table 7 Negative binomial regression results for the scholarly achievement

	Undergraduate thesis sup.	Master thesis sup.	PhD thesis sup.	Articles	Books	Prototypes and patents
Did post-doc early in the career	0.054 (0.12)	−0.0346 (0.11)	0.337** (0.16)	0.225*** (0.084)	0.123 (0.20)	−0.343 (0.37)
Mexican nationality	0.310** (0.15)	0.0234 (0.15)	0.0175 (0.26)	−0.103 (0.10)	0.183 (0.24)	−0.225 (0.52)
Age	0.00133 (0.0058)	0.0152*** (0.0055)	0.0351*** (0.0084)	−0.0158*** (0.0045)	0.032*** (0.0091)	0.0607*** (0.021)
Male	−0.0502 (0.10)	0.312*** (0.11)	0.0553 (0.15)	0.129* (0.078)	−0.0264 (0.17)	1.388*** (0.47)
Teach graduate only	0.0547 (0.30)	0.367** (0.16)	−0.386 (0.46)	−0.00449 (0.19)	0.403 (0.43)	−1.142 (1.10)
Teach undergraduate only	−0.0624 (0.12)	−0.751*** (0.16)	−0.781*** (0.25)	−0.215** (0.089)	0.229 (0.19)	0.140 (0.34)
Average student per course	0.00791** (0.0040)	−0.00623 (0.0042)	−0.0121 (0.0076)	0.000699 (0.0031)	−0.00353 (0.0072)	−0.00547 (0.012)
R&D funding sources: internal	0.209 (0.16)	−0.0188 (0.17)	0.489* (0.25)	0.165 (0.13)	0.186 (0.26)	−0.0879 (0.58)
R&D funding sources: external	0.0852 (0.14)	0.137 (0.13)	0.668*** (0.23)	0.221* (0.11)	0.0871 (0.23)	0.858* (0.44)
Other job outside academia	0.186** (0.094)	0.393*** (0.090)	0.399*** (0.14)	−0.058 (0.069)	0.631*** (0.15)	0.562* (0.32)
Science field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Institutional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.0560 (0.40)	−0.394 (0.38)	−2.068*** (0.66)	1.996*** (0.31)	−1.960*** (0.70)	−6.512*** (1.70)
Wald test	88.05***	169.72***	3558.68***	108.44***	3362.66***	6973.14***
Observations	437	437	437	437	437	437

Note: Standard errors are in parentheses. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05 and 0.10 levels, respectively

academic career and a prolific scientific production along the career (e.g., Creamer and McGuire 1998).

When the analysis is performed taking into account the place where the scholars did the post-doc, it is once again understood that performing the post-doctorate abroad brings benefits to the scientific system (Tables 8, 9). However, these benefits tend to be apparent only when all scholars from all age cohorts are considered. The scholars that did a post-doc abroad supervised 25% more doctoral students' theses and produced 24% more articles in refereed journals in the last 2 years than their peers that did not undertake a post-doctoral period.[10] These results, however, are not found for the younger cohort of scholars that did a post-doc abroad since their production of teaching, research or outreach outputs do not differ from that of their peers without a post-doc. It is probable that these results reflect the "costs" of performing a post-doctoral period abroad, which tend to be related with returning/homecoming issues. These include the difficulties of incorporating external knowledge to the institution where they are currently based (see Melin 2005), something that can be a particularly thorny issue in a higher education system such as the Mexican, where institutional loyalty can be emphasized over scientific loyalty (Padilla 2008).

Perhaps more surprising is the recent productivity of scholars that performed a post-doc at UNAM. For the whole sample, their research productivity does not differ from their peers without a post-doc, but they also supervised 28% less doctoral theses than the latter. For the younger cohort of scholars, the results of the academics that were former post-docs at UNAM are similar to the results presented for the ones that did it abroad. Although there are negative significant results concerning the supervision of doctoral theses and the production of patents and prototypes, the marginal effects are negligible (both are just slightly above zero; see Table 16 in the appendix). Since 50% of former UNAM post-docs remain currently at UNAM, a regression analysis was performed for the UNAM alone concerning teaching, research and outreach outputs.[11] The obtained results confirm the ones shown in Table 8. At UNAM, and concerning the production of scientific outputs, only the scholars that spent a post-doctoral period abroad are able to produce more articles in peer-review journals than their colleagues that did not performed a post-doc earlier in their careers. There are no differences concerning scientific production reported between either UNAM former post-docs or former post-docs at other Mexican universities and their colleagues without a post-doc. In this case, future research is required to better understand the results of the former post-docs from UNAM both concerning their recent information exchange dynamics and scholarly production.

Also surprising is the result for the scholars which undertook their post-doc at a Mexican university other than UNAM. For the whole sample, they produce 46% more articles in refereed journals than their colleagues that did not perform a post-doc. These post-docs seem to have been strongly socialized to perform research because their productivity in teaching and outreach is not different from the scholars that have not performed a post-doc earlier in their careers.[12] However, when the results are performed for the younger cohort of scholars these effects are not present, since there are no differences concerning the production of research outputs. The only difference is that

[10] See Table 15 in the appendix.

[11] Not shown in the article, but regression table can be provided upon request. The regression analysis was only performed to the full age range of scholars due to the limited number of available observations.

[12] Both for the whole sample and for the young cohort of scholars they have a negative result regarding the production of patents and prototypes, but the marginal effects are basically zero (see Table 16 in the appendix).

Table 8 Negative binomial regression results for the scholarly achievement, by locality where the post-doctoral period was performed

	Undergraduate thesis sup.	Master thesis sup.	PhD thesis sup.	Articles	Books	Prototypes and patents
Did post-doc abroad early in the career	0.108 (0.12)	−0.003 (0.11)	0.370** (0.17)	0.223** (0.090)	0.173 (0.22)	−0.248 (0.39)
Did post-doc at UNAM early in the career	−0.164 (0.32)	−0.475 (0.29)	−0.644* (0.39)	0.159 (0.21)	0.322 (0.41)	−0.429 (0.80)
Did post-doc at other Mexican University early in the career	−0.388 (0.56)	−0.076 (0.26)	0.517 (0.46)	0.378** (0.16)	−0.884 (0.58)	−17.13*** (0.73)
Mexican nationality	0.306** (0.15)	0.018 (0.15)	0.010 (0.26)	−0.106 (0.10)	0.186 (0.24)	−0.294 (0.52)
Age	0.001 (0.01)	0.016*** (0.01)	0.037*** (0.01)	−0.016*** (0.01)	0.031*** (0.01)	0.061*** (0.02)
Male	−0.041 (0.10)	0.303*** (0.11)	0.041 (0.15)	0.125 (0.078)	−0.041 (0.17)	1.390*** (0.47)
Teach graduate only	0.055 (0.29)	0.361** (0.16)	−0.397 (0.46)	−0.004 (0.19)	0.400 (0.43)	−1.178 (1.11)
Teach undergraduate only	−0.054 (0.12)	−0.759*** (0.16)	−0.801*** (0.24)	−0.219** (0.089)	0.223 (0.19)	0.122 (0.34)
Average student per course	0.008** (0.004)	−0.006 (0.004)	−0.012 (0.008)	0.001 (0.003)	−0.004 (0.007)	−0.009 (0.012)
R&D funding sources: internal	0.215 (0.16)	−0.0205 (0.17)	0.443* (0.25)	0.162 (0.13)	0.222 (0.26)	0.005 (0.58)
R&D funding sources: external	0.101 (0.14)	0.135 (0.13)	0.626*** (0.22)	0.214* (0.11)	0.107 (0.23)	0.881** (0.44)
Other job outside academia	0.199** (0.095)	0.382*** (0.090)	0.352** (0.14)	−0.066 (0.070)	0.654*** (0.15)	0.584* (0.32)
Science field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Institutional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.055 (0.40)	−0.401 (0.38)	−2.089*** (0.66)	1.999*** (0.31)	−1.981*** (0.70)	−6.451*** (1.67)
Wald test	84.30***	174.64***	2408.60***	113.06***	3285.79***	6447.51***
Observations	437	437	437	437	437	437

Note: Standard errors are in parentheses. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05 and 0.10 levels, respectively

Table 9 Negative binomial regression results for the scholarly achievement, by locality where the post-doctoral period was performed and regarding scholars aged between 31 and 42 years old

	Undergraduate thesis sup.	Master thesis sup.	PhD thesis sup.	Articles	Books	Prototypes and patents
Did post-doc abroad early in the career	0.382 (0.25)	−0.290 (0.26)	−0.862 (0.73)	0.172 (0.16)	0.298 (0.50)	−0.397 (1.01)
Did post-doc at UNAM early at the career	0.047 (0.55)	−0.232 (0.56)	−16.39*** (1.04)	0.034 (0.43)	0.175 (1.46)	−17.72*** (1.99)
Did post-doc at other Mexican University early in the career	0.126 (0.83)	−1.156** * (0.43)	1.876 (1.54)	0.169 (0.23)	0.443 (0.77)	−16.31*** (1.60)
Mexican nationality	0.432 (0.37)	−0.126 (0.30)	−0.536 (0.47)	−0.140 (0.16)	−0.428 (0.72)	9.978*** (2.61)
Age	0.031 (0.03)	0.082** (0.04)	0.174 (0.12)	0.010 (0.02)	0.015 (0.08)	0.177 (0.21)
Male	−0.101 (0.28)	0.427 (0.32)	1.229 (0.82)	0.184 (0.17)	0.451 (0.51)	15.07*** (1.90)
Teach graduate only	0.161 (0.45)	0.398 (0.35)	−0.890 (0.97)	0.234 (0.25)	1.459** (0.66)	−13.73*** (0.88)
Teach undergraduate only	0.011 (0.28)	−0.862** (0.34)	−0.675 (0.57)	−0.172 (0.16)	0.230 (0.63)	0.518 (0.80)
Average student per course	0.008 (0.01)	−0.014 (0.01)	−0.056*** (0.02)	0.007 (0.01)	0.011 (0.02)	0.092 (0.07)
R&D funding sources: internal	−0.343 (0.50)	0.386 (0.52)	14.87*** (0.66)	−0.009 (0.27)	−1.956 (1.22)	−1.729 (1.38)
R&D funding sources: external	0.204 (0.42)	0.767 (0.52)	15.44*** (0.51)	0.115 (0.23)	0.475 (0.60)	−0.555 (1.14)
Other job outside academia	0.029 (0.27)	0.555** (0.24)	−0.561 (0.50)	−0.030 (0.15)	0.745 (0.50)	−0.598 (1.09)
Science field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Institutional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.961 (1.46)	−3.878** (1.85)	−21.53*** (5.56)	1.220 (1.10)	−2.707 (3.51)	−33.96*** (8.75)
Wald test	913.08***	1.9e + 10***	8276.64***	972.54***	1.6e + 08***	7879.39***
Observations	118	118	118	118	118	118

Note: Standard errors are in parentheses. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05 and 0.10 levels, respectively

former post-docs supervise 33% less master theses than their colleagues that did not performed a post-doc.

The analysis of the effects of performing a post-doc early in the career cannot, however, be limited to a general analysis at systemic level since it is known that the post-doctoral period assumes different relevance by scientific field. In some scientific fields, undertaking a post-doctoral period is almost mandatory, while in others performing a post-doc is not usual at all (e.g., Stephan and Ma 2005). Cahozac and Robin (2003), for example, concluded that doing a post-doc is much more common in the life sciences than in engineering. These differences reflect not only different academic and labor market dynamics, but also different scientific field traditions and identities (Henkel 2004). This is particularly important in the most advanced levels of postgraduate education which is the period where the foundations of academic and disciplinary identity are most sharply shaped (Henkel 2005).

The effects of holding a post-doc by scientific field

Table 10 shows the estimates, by scientific field, of information exchange dynamics between Mexican academics and international peers in the several information exchange categories.[13] The results reveal significant differences by scientific field. The positive effects of holding a post-doc early in the academic career regarding the information exchange behavior are particularly evident in the health sciences and humanities.[14] In contrast, holding a post-doc earlier in the career does not lead a faculty member in engineering to have greater information exchange with international peers.

Nonetheless, the effects of holding a post-doc foster information exchange with international colleagues later in the career in distinct scientific fields such as the exact sciences and the social sciences. In the exact sciences, faculty members who held a post-doc tend to have a higher information exchange intensity with international peers on research and teaching activities, innovative subjects and articles, and equipment and research techniques than their counterparts who did not hold a post-doc. In the social sciences, faculty members who held a post-doc also showed higher information exchange intensity with international peers on research and teaching activities, as well as on innovative subjects and articles than their colleagues who did not hold a post-doc position.

For all scientific fields, except engineering, there are benefits in terms of information exchange dynamics with the international scientific and academic communities from holding a post-doc earlier in the career, thus reinforcing the results of the analysis for the higher education system as a whole.

The positive effect of holding a post-doctoral position is deemed to foster the integration of the national academic scientific base within the international community for most scientific fields. It is then also important to understand if the effects of holding a post-doc also impact positively on academic scholarly production in distinct fields. This is shown in Table 11. The analysis by scientific field is only performed for the teaching and

[13] Due to the reduced number of observations the analysis by scientific field is only performed for the whole sample.

[14] In the humanities, the only non significant category of information exchange with international peers is on research and teaching activities.

Table 10 Regression results for information exchange dynamics, by scientific field

	Did post-doc	Mexican	Age	Male	Teach_ grad_only	Teach_ underonly	Avg_stu_ courses	R&D fund_int	R&D fund_ext	Other job outside academia	Wald test	Obs
Health sciences												
Research and teaching activities	0.819***	−0.115	−0.0126	0.745**	−9.244***	−0.0859	−0.00561	0.805	0.153	0.206	7239.48***	44
Innovative subjects and articles	0.866***	−1.184***	−0.0204***	0.523*	−10.48***	0.0154	−0.0218**	0.847	0.598	0.260	8573.23***	44
Equipment and research techniques	1.274***	−1.278***	0.0135	0.683	−2.428***	0.547	−0.0160*	0.809	−0.244	0.891*	2197.67***	44
Financial sources for research	0.874***	−0.968***	−0.0343***	1.128***	−0.396	0.0586	0.00666	0.0508	−0.254	0.245	3379.35***	44
Publish and diffusion of research results	0.938***	−0.483	−0.0519**	0.790	−9.382***	0.647	−0.0122	−0.127	−0.424	0.637	4191.07***	44
Job opportunities	0.897***	0.104	−0.0488***	0.884**	−7.978***	−0.435	−0.0125	−0.282	−0.479	0.0839	2470.70***	44
Exact sciences												
Research and teaching activities	0.328***	0.517	0.00365	−0.125	−0.286	−0.222	−0.00958	−0.171	0.576*	0.298	1373.75***	140
Innovative subjects and articles	0.326**	−0.128	−0.00999	−0.271*	0.0217	−0.360**	−0.00728	−0.659*	0.331	0.478***	1338.69***	140
Equipment and research techniques	0.429***	0.268	−0.0126	−0.239	−0.273	−0.208	−0.00979	−0.0577	0.534*	0.369**	345.26***	140
Financial sources for research	0.0225	−0.0952	−0.0201	0.107	0.331	−0.549**	−0.00400	−0.152	0.604*	0.244	486.70***	140
Publish and diffusion of research results	0.228	0.0926	−0.0124	0.0593	−0.000581	−0.255	−0.00356	−0.333	0.684**	0.383***	998.71***	140
Job opportunities	0.262	0.415	−0.0160	−0.00918	0.0342	−0.571**	−0.0123	−0.501	0.273	0.188	2455.67***	140
Social sciences												
Research and teaching activities	1.520***	−0.0195	0.00625	−0.438***	1.039**	0.273	0.0244**	0.867***	0.981***	−0.0979	582.39***	78
Innovative subjects and articles	1.059***	0.393	−0.00530	−0.527	0.593**	0.811**	0.00176	0.889***	0.836**	0.0216	80.70***	78
Equipment and research techniques	0.319	0.174	0.0155	−0.791***	0.897***	0.591**	0.0155	0.802***	0.517	0.187	316.72***	78
Financial sources for research	0.130	−0.111	−0.0154	−0.715***	0.322	0.482	0.0140	1.099***	0.809	0.256	411.68***	78

Table 10 continued

	Did post-doc	Mexican	Age	Male	Teach_ grad_only	Teach_ underonly	Avg_stu_ courses	R&D fund_int	R&D fund_ext	Other job outside academia	Wald test	Obs
Publish and diffusion of research results	0.359	0.162	−0.00801	−0.331	0.586	0.252	0.00825	0.639**	0.733**	0.0783	104.56***	78
Job opportunities	0.195	0.345	−0.0138	−0.458*	0.199	0.492	0.00200	0.798***	0.873	−0.0188	154.60***	78
Humanities												
Research and teaching activities	1.152	−0.845**	−0.0307	−0.247	−9.038***	−0.183	0.0226	0.349	0.330	−0.0303	19687.17***	48
Innovative subjects and articles	1.932**	−0.929**	−0.0384***	−0.279	8.102***	−0.639**	0.00754	0.685	0.605	−0.537*	2544.10***	48
Equipment and research techniques	1.819***	−0.487	−0.0226	0.147	−0.290	−1.053**	0.0137	0.190	0.213	0.0813	378.97***	48
Financial sources for research	1.504***	−0.762*	−0.0502*	0.256	8.380***	−0.831	−0.00248	−0.185	0.391	0.0110	11409.39***	48
Publish and diffusion of research results	2.147***	−0.910**	−0.0555**	−0.300	7.651***	−1.106**	0.00919	0.327	0.181	−0.315	3180.34***	48
Job opportunities	1.900***	−0.526	−0.0221	−0.0723	9.306***	−0.543	−0.00309	0.669	0.776	−0.215	29914.38***	48
Engineering												
Research and teaching activities	−0.102	−0.0870	0.00820	0.164	0.476	−0.443	−0.00541	−0.222	0.254	0.571***	309.34***	100
Innovative subjects and articles	0.213	0.0825	−0.0110	0.115	−0.256	−0.109	−0.0140	0.0919	0.311	0.658***	162.57***	100
Equipment and research techniques	0.173	0.0581	−0.0103	0.0138	−0.279	−0.0535	−0.00392	0.117	0.549**	0.703***	75.86***	100
Financial sources for research	0.385	0.149	−0.0255***	0.297	−0.214	−0.0506	−0.00684	0.390	0.744***	0.553***	385.06***	100
Publish and diffusion of research results	0.261	0.0118	−0.0218***	0.378	−0.111	−0.0350	−0.00678	0.442	0.368**	0.336**	1179.94***	100
Job opportunities	0.427	−0.256	0.00315	−0.0513	−0.0396	−0.149	−0.0270***	0.753**	0.313	0.363	36.97***	100

Note: Only the coefficients are shown. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05 and 0.10 levels, respectively

Table 11 Regression results for scholarly production (teaching and research functions), by scientific field

	Did post-doc	Mexican	Age	Male	Teach_ grad_only	Teach_ underonly	Avg_stu_ courses	R&D fund_int	R&D fund_ext	Other job outside academia	Constant	Wald test	Obs
Health sciences													
Undergraduate thesis sup.	0.347*	1.256***	−0.0132	−0.247	−19.59***	0.306**	−0.00496	0.346	0.323	0.216	−0.0344	459.10***	45
Master thesis sup.	0.244	0.696***	0.0319***	0.714***	1.632***	−0.395	−0.00865	0.567*	0.170	0.656**	−2.489***	1.1e + 10***	45
PhD thesis sup.	0.492***	1.110**	0.0365***	0.791**	2.990***	−0.863	−0.00728	1.800***	0.717***	−0.269	−4.138***	2.3e + 09***	45
Articles	0.246**	0.0811	−0.0372***	0.241	−19.25***	−0.268	0.0133	−0.450**	−0.0346	−0.156	2.710***	581.63***	45
Books	0.650	1.615***	0.0795***	−0.152	−0.0705	0.254	−0.0150	1.050**	0.741**	1.641***	−6.629***	2684.85***	45
Exact sciences													
Undergraduate thesis sup.	−0.0657	0.478**	0.0238*	−0.286*	0.169	−0.211	−0.000766	0.975***	0.740*	0.258	−1.519*	2883.19***	143
Master thesis sup.	−0.380***	−0.335	0.0322***	0.0199	−0.121	−0.789***	0.00714	−0.364	0.455	0.424**	−1.551**	541.91***	143
PhD thesis sup.	0.415	0.127	0.0398***	−0.00719	0.204	−0.752**	−0.000193	0.384	1.423**	0.384	−3.937***	909.93***	143
Articles	0.156***	−0.224*	−0.0169***	0.0217	−0.362	−0.150	−0.00365	0.754***	0.614***	0.0912	1.662***	321.56***	143
Books	−0.474***	0.177	0.0540***	−0.104	2.407**	0.0353	0.00916	−0.938	−1.275*	1.749***	−3.015**	8133.53***	143
Social sciences													
Undergraduate thesis sup.	−0.148	0.516	0.000558	0.310	−0.396	0.162	0.00940	−0.199	−0.259	−0.0784	0.309	273.67***	84
Master thesis sup.	0.529*	−0.210	−0.00150	0.290	0.424	−0.548	−0.0201	0.235	0.260	0.754***	0.243	80.91***	84
PhD thesis sup.	0.330	0.108	0.0572***	0.0747	−15.47***	−1.302	−0.0398*	0.299	0.185	0.659***	−3.067	2002.17***	84
Articles	−0.184	0.188	−0.00497	0.0753	0.0492	0.111	−0.00212	0.0257	0.243	−0.107	1.152**	41.88***	84
Books	0.399*	0.590***	0.00178	−0.188	−0.0838	0.812**	−0.00407	0.420	0.154	0.357	−0.291	239.55***	84
Humanities													
Undergraduate thesis sup.	−0.239	0.225	0.0134	0.309	−20.24***	0.482	−0.00958	0.322	0.104	0.235	−0.184	565.94***	49

Table 11 continued

	Did post-doc	Mexican	Age	Male	Teach_ grad_only	Teach_ underonly	Avg_stu_ courses	R&D fund_int	R&D fund_ext	Other job outside academia	Constant	Wald test	Obs
Master thesis sup.	0.370	0.370	0.0176	0.274	−20.77***	−0.537	0.00105	−0.895***	−0.274	0.197	−0.622	671.63***	49
PhD thesis sup.	−1.133*	0.611	0.132***	−0.543	−25.69***	−0.798	−0.0577***	1.688**	1.184	−0.706	−6.942***	1070.01***	49
Articles	0.00311	−0.256*	−0.00561	−0.119	0.105	0.156	−0.0133	0.594*	0.719**	−0.573***	1.656**	2740.41***	49
Books	−1.327	−0.276	−0.0229	−0.0345	2.698**	0.783**	0.0131	0.431	0.586	0.0650	0.858	77.26***	49
Engineering													
Undergraduate thesis sup.	0.00397	−0.00423	0.00275	0.199	−0.278	−0.243	0.0270*	−0.0944	0.167	0.188	−0.0682	39.06***	103
Master thesis sup.	−0.0705	0.151	0.0250***	0.708***	0.418**	−1.375***	−0.0154**	0.522*	0.292*	0.237**	−1.315**	994.55***	103
PhD thesis sup.	−0.117	−0.541	0.0196*	0.237	−0.969	−0.834***	−0.0129	0.340	0.853*	0.135	−1.422	243.76***	103
Articles	0.265*	−0.103	−0.0210**	0.440	0.236	−0.615***	−0.000693	−0.297	0.0248	−0.478***	2.030***	263.12***	103
Books	0.308	0.0518	0.0814**	1.598**	−0.323	0.263	−0.0379	0.658	1.211*	0.471	−6.330***	372.70***	103

Note: Only the coefficients are shown. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05 and 0.10 levels, respectively

research functions of the university. It is as such because as the summary statistics indicate (see Table 1), the extremely low number of prototypes and patents make any consistent analysis of the outreach function of the university unfeasible. Furthermore, these scholarly outputs tend to be mostly related with two (mostly three) scientific fields. It would not make much sense, for instance, to do a prototype and patent analysis for the humanities or for the social sciences.

The effects of holding a post-doc have positive effects mainly in the research function of the university. In the health sciences, exact sciences, and engineering, faculty members who held a post-doc produce more articles in refereed journals than those who did not hold a post-doc. The significant and positive effect of holding a post-doc regarding the production of articles in refereed journals for these scientific fields demonstrates the critical importance of holding a post-doc early in the academic career, as the production of articles in refereed journals is the preferred means of diffusion of research results in these scientific fields (Levin and Stephan 2001). In this context, the negative effect that holding a post-doc has on the production of books in the exact sciences is rather unimportant, since this is not the primary form of scientific communication in that particular field. The above results also show that, despite the fact that holding a post-doc position at the beginning of the academic career in engineering does not seem to foster increased information exchange, it has a positive effect on increasing the research production in that field.

The positive effects of holding a post-doc are also perceived in the social sciences. Faculty members who held a post-doc write more books (a critical scientific output in the social sciences) than faculty members who did not hold a post-doc. The only scientific field where holding a post-doc has no effect in the research production of faculty members is the humanities.

On the teaching function of the university, results are mixed. If in the health sciences holders of a post-doctoral position tend to supervise more undergraduate and doctoral theses, in the exact sciences they tend to supervise less masters theses and in the humanities less doctoral theses. In the social sciences, faculty members with a post-doc supervise only more masters theses and, in the engineering field, holding a post-doc is not a decisive factor to supervising more or less theses and, therefore, has no impact on supervision. The mixed results on teaching seem to underline the fact that holding a post-doc is particularly beneficial for the research function of the university, but not necessarily for its teaching function.

Conclusion

In this article, the impact that doing a post-doc has on scholarly production and on the integration in international academic networks by academics of a country that is struggling to enlarge and improve its academic research base is assessed. It is found that academics that did a post-doc tend to exchange information on scientific and academic subjects with their international peers more frequently than their colleagues without a post-doc. The fact that faculty members with a post-doc are more intensively engaged in information exchange with international peers highlights the importance of postdoctoral study in any national scientific system. Post-doctoral academics have the potential to become key players, bridging knowledge between national and international scientific and scholarly networks. This is particularly evident in the younger generations of scholars and in those

that have spent the post-doctoral period in institutions outside of the Mexican higher education system.

The results suggest that international mobility at the time of the post-doc is critical. The empirical results of this article support Melin's (2004) analysis that the post-doctoral period spent abroad has the effect of integrating academics in the international community, while at the same time functioning as an enabler of scientific collaboration. It is known that mobility is deemed to foment contacts and knowledge transfer, but this article research shows that in order to reap long-term benefits in terms of international openness from the post-doctoral period, it is increasingly relevant that this period is spent beyond national borders. In an increasingly global world where a growing number of scholarly activities are performed at international level such assessment makes sense. After all, knowledge flows are increasingly global and the active participation and engagement in internationally-oriented networks is critical to absorb the most advanced knowledge and learning methodologies for academic research and teaching practices (Mahroum 2000).

The analysis also shows that academics that did a post-doc earlier in their careers also tend to have higher scientific outputs than their colleagues. The post-doc period has a strong impact on the publication behavior of academics, and this is not surprising as the post-doc, which is usually carried out immediately after the completion of the doctoral degree or within a few years of its completion, is undertaken at a time when the scholarly identity of the academic is being forged (see Henkel 2004). For most of the scientific fields, academics with a post-doc have a greater scientific output in the preferred means of dissemination in their respective fields (except for the humanities, where holding a post-doc has no impact on scientific output). In contrast, holding a post-doc does not have any significant impact on the teaching or outreach functions of the university, in spite of the fact that academics holding a post-doc supervise 18% more doctoral theses than their colleagues who did not do a post-doc. However, the doctoral thesis has in many cases a larger component of research than teaching. The inconsistent results regarding teaching activities by scientific field suggest that the critical impact of doing a post-doc for the academic career productivity affects the development of research activities, not teaching activities.

Overall, the results from this research indicate that public funding of post-doc fellowships can be a good investment for the academic research development of a country, and therefore, for the development of a country scientific system if at the end of the post-doctoral period, post-docs are hired as faculty. If this is the case, then this article shows that a greater scientific production and a more frequent and stable interaction with the international scholarly community is bound to happen, something that is critical for countries developing their scientific base such as Mexico.

Appendix

See Tables 12, 13, 14, 15, and 16.

Table 12 Correlations table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
Supervision undergraduate thesis (1)	1.00																									
Supervision master thesis (2)	0.05	1.00																								
Supervision PhD thesis (3)	0.01	0.40	1.00																							
Articles (4)	0.12	0.01	0.05	1.00																						
Books (5)	0.09	0.13	0.17	0.03	1.00																					
Prototypes and patents (6)	-0.01	0.03	0.09	-0.01	-0.07	1.00																				
I.e. research and teaching activities (7)	-0.05	0.13	0.18	0.08	0.08	0.05	1.00																			
I.e. innovative subjects and articles (8)	-0.02	0.09	0.16	0.10	0.16	-0.06	0.63	1.00																		
I.e. equipment and research techniques (9)	0.00	0.11	0.11	0.14	0.09	0.00	0.59	0.71	1.00																	
I.e. financial sources for research (10)	-0.03	0.16	0.12	0.11	0.10	-0.01	0.55	0.63	0.69	1.00																
I.e. publishing and diffusion of research results (11)	0.01	0.15	0.12	0.14	0.13	-0.02	0.51	0.67	0.64	0.74	1.00															
I.e. job opportunities (12)	0.03	0.16	0.12	0.11	0.08	-0.02	0.49	0.53	0.57	0.62	0.60	1.00														
Did post-doc early in the career (13)	-0.04	0.03	0.12	0.14	-0.01	0.04	0.14	0.14	0.17	0.11	0.11	0.18	1.00													
Did post-doc abroad early in the career (14)	-0.02	0.05	0.15	0.13	0.00	0.06	0.13	0.10	0.13	0.08	0.10	0.18	0.89	1.00												
Did post-doc at UNAM early in the career (15)	-0.03	-0.08	-0.06	0.02	0.02	-0.01	0.05	0.08	0.11	0.08	0.05	0.05	0.30	-0.07	1.00											
Did post-doc in other Mexican university (16)	-0.04	0.03	0.02	0.05	-0.05	-0.03	0.00	0.06	0.03	0.05	-0.01	-0.04	0.23	-0.06	-0.02	1.00										
Mexican nationality (17)	0.10	0.02	0.01	-0.01	0.01	0.04	-0.01	-0.06	0.00	-0.02	-0.01	0.06	0.00	0.02	-0.04	-0.02	1.00									
Age (18)	0.08	0.12	0.23	-0.14	0.22	0.08	0.01	-0.05	-0.03	-0.15	-0.11	-0.09	0.04	0.03	0.02	-0.01	-0.10	1.00								
Male (19)	0.00	0.16	0.03	0.06	-0.05	0.13	0.00	-0.06	-0.03	0.05	0.03	0.05	0.12	0.13	-0.03	0.04	0.09	-0.01	1.00							
Teach graduate only (20)	-0.05	0.17	-0.05	0.02	-0.03	-0.04	0.05	0.03	0.02	0.05	0.04	0.07	0.01	0.00	0.03	-0.03	-0.07	-0.07	0.02	1.00						
Teach undergraduate only (21)	-0.03	-0.28	-0.18	-0.12	0.03	0.00	-0.13	-0.12	-0.06	-0.10	-0.10	-0.10	-0.09	-0.07	0.00	-0.06	-0.04	-0.05	0.02	-0.12	1.00					
Average student per course (22)	0.08	-0.12	-0.08	-0.02	-0.01	-0.06	-0.03	-0.07	-0.04	-0.04	-0.03	-0.13	-0.01	0.02	0.01	-0.12	0.03	-0.01	-0.15	-0.16	0.04	1.00				
R&D funding sources: internal (23)	0.05	-0.04	-0.01	-0.03	0.08	-0.06	-0.07	-0.07	-0.05	-0.07	-0.05	-0.05	-0.07	-0.06	-0.03	0.00	0.04	0.09	0.10	-0.05	0.03	0.11	1.00			
R&D funding sources: external (24)	-0.04	0.06	0.12	0.14	-0.06	0.10	0.18	0.15	0.14	0.17	0.13	0.13	0.07	0.06	0.02	0.01	0.03	-0.10	-0.02	0.00	-0.05	-0.09	-0.61	1.00		
Other job outside academia (25)	0.10	0.21	0.11	-0.05	0.14	0.07	0.10	0.11	0.14	0.12	0.10	0.04	0.00	-0.01	-0.05	0.07	-0.03	0.01	0.08	0.00	-0.12	0.00	0.04	0.00	1.00	
Agrarian sciences (26)	0.04	-0.02	-0.01	0.01	-0.01	-0.02	-0.06	-0.09	-0.07	-0.01	-0.06	-0.01	-0.09	-0.08	-0.03	-0.02	0.07	-0.05	0.06	-0.04	0.04	-0.10	-0.01	0.05	0.04	1.00
Health sciences (27)	-0.13	-0.18	-0.05	0.03	-0.16	0.05	0.06	0.00	0.06	0.02	-0.02	0.06	0.23	0.19	0.12	0.04	0.08	-0.13	0.00	-0.07	0.07	0.08	-0.05	0.11	-0.04	-0.13
Exact sciences (28)	0.09	0.00	0.03	-0.04	0.21	-0.10	-0.01	0.14	0.02	0.02	0.09	-0.01	-0.13	-0.13	-0.03	-0.01	-0.04	0.13	-0.12	0.03	-0.08	-0.03	0.06	-0.15	0.08	-0.08
Social sciences (29)	0.05	-0.01	-0.04	-0.02	0.06	-0.05	-0.02	0.04	-0.09	-0.05	0.05	-0.11	-0.11	-0.11	-0.06	0.02	-0.14	0.05	-0.13	-0.05	-0.04	0.09	0.05	-0.13	-0.02	-0.06
Humanities (30)	0.04	0.15	-0.03	-0.03	-0.08	0.09	-0.01	-0.09	-0.01	0.01	-0.05	0.01	-0.05	-0.03	-0.05	-0.02	0.02	-0.08	0.23	0.15	0.01	-0.17	-0.01	0.07	-0.03	-0.10
hei3	-0.15	0.09	-0.03	-0.02	0.03	-0.04	0.05	0.03	0.01	0.07	0.04	0.03	-0.05	-0.04	-0.03	-0.02	-0.07	-0.13	-0.07	0.22	-0.09	0.01	-0.04	0.04	0.05	-0.03
hei4	-0.02	-0.05	-0.02	-0.01	-0.05	0.02	0.03	0.04	0.09	0.08	0.04	-0.04	-0.05	-0.05	-0.02	-0.01	-0.04	-0.05	0.01	-0.02	0.01	-0.01	-0.05	-0.03	-0.07	-0.02
hei5	-0.10	0.06	0.04	0.16	-0.10	0.07	0.07	-0.02	0.05	0.05	0.03	0.04	-0.01	0.00	-0.03	-0.02	0.06	-0.15	0.11	0.23	-0.08	-0.17	0.00	0.06	-0.03	-0.03
hei19	0.02	-0.01	0.09	0.08	0.11	-0.04	0.00	0.11	0.05	0.00	0.03	0.01	-0.09	-0.08	-0.03	-0.02	-0.07	0.17	-0.08	0.03	0.03	-0.06	0.00	0.00	-0.03	-0.03
hei21	0.08	0.04	-0.08	-0.03	-0.06	-0.05	-0.08	-0.15	-0.14	-0.11	-0.09	-0.09	-0.04	-0.02	-0.04	-0.03	-0.02	-0.05	0.07	0.11	0.01	-0.02	-0.02	-0.02	-0.04	-0.05
hei22	-0.06	0.01	-0.05	-0.07	-0.02	-0.02	-0.04	0.06	-0.03	0.01	0.05	0.00	0.02	-0.04	-0.01	0.23	0.03	0.04	-0.07	-0.02	-0.04	-0.06	-0.04	-0.11	-0.01	-0.02
hei23	0.00	-0.01	0.08	0.07	0.02	0.01	-0.04	0.06	0.04	0.06	0.03	-0.07	-0.04	-0.03	-0.04	-0.01	-0.01	-0.02	-0.07	-0.12	0.05	0.14	-0.05	0.09	-0.05	-0.09
hei28	-0.01	-0.02	-0.03	-0.05	0.02	-0.03	0.04	0.00	-0.06	-0.03	-0.09	-0.01	0.00	0.01	-0.02	-0.01	-0.03	-0.04	-0.07	-0.03	-0.06	0.10	0.01	-0.05	0.10	-0.02
hei34	0.10	-0.05	-0.07	0.00	-0.03	-0.03	-0.06	-0.10	-0.08	-0.10	-0.09	-0.08	-0.06	-0.05	-0.02	-0.01	0.04	-0.02	0.07	-0.03	0.05	-0.02	0.01	0.04	0.05	0.61
hei42	-0.03	-0.01	-0.09	-0.07	-0.02	0.06	0.07	0.01	0.06	0.04	0.04	0.10	-0.03	-0.01	-0.03	-0.02	0.07	-0.06	0.09	0.02	0.04	-0.09	-0.08	0.08	0.01	0.21
hei43	0.08	0.12	0.05	-0.04	0.08	-0.04	-0.03	-0.03	-0.03	0.03	0.02	0.02	-0.04	-0.03	-0.02	-0.02	0.06	0.01	0.10	-0.03	-0.08	-0.09	-0.03	0.01	0.06	-0.03
hei46	0.05	0.02	-0.06	0.04	-0.03	0.02	0.01	0.08	0.07	0.07	0.05	0.05	-0.04	-0.06	-0.03	0.09	0.03	-0.08	0.07	-0.04	0.03	-0.07	0.01	-0.09	-0.04	-0.03
hei51	-0.02	-0.16	-0.05	0.03	-0.10	0.07	0.00	0.05	0.02	0.03	0.01	0.06	0.10	0.04	0.11	0.07	0.02	-0.15	-0.02	0.05	0.02	-0.12	-0.10	0.05	-0.03	0.02
hei56	-0.09	0.02	-0.06	-0.15	-0.04	0.02	0.00	0.06	0.07	0.11	0.11	0.09	0.00	0.02	-0.02	-0.02	-0.04	-0.12	0.03	0.04	0.00	0.06	0.06	-0.09	0.09	-0.03
hei63	-0.01	-0.04	-0.07	-0.01	-0.05	-0.02	0.01	0.04	0.05	0.03	0.06	0.07	0.05	-0.04	0.16	0.10	-0.02	-0.04	-0.07	0.02	0.05	0.00	-0.04	-0.02	-0.04	-0.03
hei65	0.08	-0.06	-0.10	-0.02	0.02	-0.05	0.01	0.00	0.01	0.02	0.02	0.06	-0.08	-0.07	-0.03	-0.03	-0.06	-0.01	-0.01	-0.05	0.03	-0.04	-0.04	0.11	0.08	0.03
hei66	0.04	-0.04	-0.05	-0.07	0.00	-0.03	-0.06	-0.06	-0.06	-0.08	-0.06	-0.07	-0.02	-0.01	-0.02	-0.02	-0.06	0.10	0.09	-0.03	-0.07	-0.01	0.08	-0.13	0.02	-0.02
hei68	0.05	-0.02	-0.05	0.03	-0.07	-0.03	0.05	0.01	0.05	0.05	0.04	0.02	0.02	0.04	-0.02	-0.02	-0.01	-0.06	-0.03	-0.03	-0.02	0.10	-0.06	0.06	0.02	-0.02
hei75	-0.05	0.05	0.08	-0.02	0.02	0.01	0.04	0.04	0.04	0.07	0.03	0.04	0.00	0.01	-0.02	-0.01	0.04	-0.02	-0.02	-0.03	0.05	-0.05	0.01	-0.01	0.01	0.36
hei84	0.07	-0.04	-0.09	-0.13	-0.02	-0.03	-0.11	-0.11	-0.12	-0.07	-0.09	-0.06	-0.07	-0.06	-0.02	-0.02	0.00	0.03	-0.06	-0.03	0.10	0.07	0.07	-0.15	0.07	-0.02

Table 12 continued

	(27)	(28)	(29)	(30)	hei3	hei4	hei5	hei19	hei21	hei22	hei23	hei28	hei34	hei42	hei43	hei46	hei51	hei56	hei63	hei65	hei66	hei68	hei75	hei84
Health sciences (27)	1.00																							
Exact sciences (28)	-0.33	1.00																						
Social sciences (29)	-0.25	-0.17	1.00																					
Humanities (30)	-0.39	-0.26	-0.20	1.00																				
hei3	-0.12	0.32	-0.06	-0.10	1.00																			
hei4	-0.07	-0.05	-0.04	0.18	-0.02	1.00																		
hei5	-0.11	-0.08	-0.06	0.29	-0.03	-0.02	1.00																	
hei19	-0.11	0.27	0.04	-0.09	-0.03	-0.02	-0.03	1.00																
hei21	-0.08	-0.12	-0.06	0.33	-0.04	-0.03	-0.04	-0.04	1.00															
hei22	-0.06	0.18	-0.03	-0.05	-0.01	-0.01	-0.01	-0.01	-0.02	1.00														
hei23	0.12	-0.02	-0.01	0.00	-0.09	-0.05	-0.08	-0.08	-0.13	-0.04	1.00													
hei28	-0.08	0.00	0.03	-0.01	-0.02	-0.01	-0.02	-0.02	-0.03	-0.01	-0.05	1.00												
hei34	-0.08	-0.05	-0.04	-0.06	-0.02	-0.01	-0.02	-0.02	-0.03	-0.01	-0.05	-0.01	1.00											
hei42	0.11	-0.08	-0.06	-0.07	-0.03	-0.02	-0.03	-0.03	-0.05	-0.02	-0.09	-0.02	-0.02	1.00										
hei43	-0.07	0.06	-0.05	-0.04	-0.03	-0.01	-0.02	-0.02	-0.04	-0.01	-0.07	-0.02	-0.02	-0.03	1.00									
hei46	-0.05	-0.06	0.05	0.13	-0.03	-0.02	-0.03	-0.03	-0.05	-0.02	-0.10	-0.02	-0.02	-0.03	-0.03	1.00								
hei51	0.22	-0.11	-0.04	-0.07	-0.04	-0.02	-0.04	-0.04	-0.06	-0.02	-0.11	-0.02	-0.02	-0.04	-0.03	-0.04	1.00							
hei56	-0.10	0.01	0.05	0.11	-0.03	-0.01	-0.02	-0.02	-0.04	-0.01	-0.07	-0.02	-0.02	-0.03	-0.02	-0.03	-0.03	1.00						
hei63	0.09	0.03	0.03	-0.10	-0.03	-0.02	-0.03	-0.03	-0.04	-0.01	-0.09	-0.02	-0.02	-0.03	-0.03	-0.03	-0.04	-0.03	1.00					
hei65	-0.07	0.05	0.15	-0.03	-0.04	-0.02	-0.03	-0.03	-0.06	-0.02	-0.10	-0.02	-0.02	-0.04	-0.03	-0.04	-0.05	-0.03	-0.04	1.00				
hei66	-0.09	0.08	0.19	-0.07	-0.02	-0.01	-0.02	-0.02	-0.03	-0.01	-0.06	-0.01	-0.01	-0.02	-0.02	-0.02	-0.03	-0.02	-0.02	-0.03	1.00			
hei68	0.03	-0.06	0.01	-0.03	-0.02	-0.01	-0.02	-0.02	-0.03	-0.01	-0.06	-0.01	-0.01	-0.02	-0.02	-0.02	-0.03	-0.02	-0.02	-0.03	-0.02	1.00		
hei75	-0.03	-0.05	0.03	-0.06	-0.02	-0.01	-0.02	-0.02	-0.03	-0.01	-0.05	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	1.00	
hei84	-0.06	0.07	0.01	-0.04	-0.02	-0.01	-0.02	-0.02	-0.04	-0.01	-0.07	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03	-0.02	-0.02	-0.03	-0.02	-0.02	-0.02	1.00

Table 13 Ordered probit regression results for the information exchange dynamics with international peers of academics that held a post-doc in comparison with academics who did not hold a post-doc position, aged between 31 and 42 years old

	Research and teaching activities	Innovative subjects and articles	Equipment and research techniques	Financial sources for research	Publish and diffusion of research results	Job opportunities
Did post-doc early in the career	0.627* (0.32)	1.110*** (0.36)	1.228*** (0.31)	1.125*** (0.31)	0.985*** (0.31)	1.400*** (0.31)
Mexican nationality	−0.621 (0.38)	−0.769** (0.39)	−0.251 (0.40)	−0.385 (0.37)	−0.502 (0.31)	−0.229 (0.40)
Age	−0.039 (0.045)	0.005 (0.043)	0.011 (0.046)	0.008 (0.046)	0.021 (0.044)	0.009 (0.048)
Male	−0.410 (0.30)	−0.175 (0.32)	−0.582* (0.31)	−0.0127 (0.33)	0.263 (0.33)	−0.303 (0.35)
Teach graduate only	−0.302 (0.36)	0.368 (0.37)	0.280 (0.43)	0.580 (0.39)	0.465 (0.42)	0.005 (0.45)
Teach undergraduate only	−0.380 (0.35)	−0.0375 (0.36)	0.254 (0.35)	−0.275 (0.36)	−0.179 (0.33)	−0.505 (0.37)
Average student per course	−0.001 (0.013)	0.002 (0.013)	−0.003 (0.014)	0.007 (0.011)	0.0181 (0.011)	−0.0001 (0.011)
R&D funding sources: internal	0.415 (0.47)	0.261 (0.50)	0.846* (0.46)	0.424 (0.48)	−0.308 (0.41)	−0.387 (0.47)
R&D funding sources: external	0.569 (0.40)	0.594 (0.46)	1.095** (0.43)	0.876** (0.38)	0.505 (0.32)	0.235 (0.40)
Other job outside academia	0.410 (0.27)	0.733** (0.33)	0.845*** (0.31)	0.965*** (0.30)	0.256 (0.27)	0.267 (0.31)
Science field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Institutional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Wald test	8030.86***	7096.34***	7788.27***	10240.53***	7943.19***	10804.61***
Observations	117	117	117	117	117	117

Note: Standard errors are in parentheses. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05 and 0.10 levels, respectively

Table 14 Effect of doing a post-doctoral period early in the academic career for faculty recent scholarly output

Variables	Sample mean	Post-doc effect	Post-doc effect/sample mean (%)
Supervision undergraduate thesis	2.10	0.11	NS
Supervision master thesis	1.40	−0.04	NS
Supervision PhD thesis	0.60	0.11**	18
Articles	3.12	0.75***	24
Books	1.09	0.08	NS
Prototypes and patents	0.12	−0.001	NS

Results on the table are marginal effects from regression estimation reported on Table 4. The ratio of the post-doctoral period early in the academic career effect over the sample is a direct algebraic estimation

NS not significant

* $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$

Table 15 Effect of doing a post-doctoral period early in the academic career for faculty recent scholarly output, by locality where the post-doctoral period was performed

Variables	Sample mean	Abroad		UNAM		Other Mexican University	
		Post-doc effect	Post-doc effect/ sample mean (%)	Post-doc effect	Post-doc effect/ sample mean (%)	Post-doc effect	Post-doc effect/ sample mean (%)
Supervision undergraduate thesis	2.10	0.22	NS	−0.30	NS	−0.64	NS
Supervision master thesis	1.40	−0.01	NS	−0.48	NS	−0.09	NS
Supervision PhD thesis	0.60	0.15**	25	−0.17*	−28	0.24	NS
Articles	3.12	0.75**	24	0.54	NS	1.42**	46
Books	1.09	0.11	NS	0.23	NS	−0.36	NS
Prototypes and patents	0.12	−0.001	NS	−0.001	NS	−0.004***	−3

Results on the table are marginal effects from regression estimation reported on Table 8. The ratio of the post-doctoral period early in the academic career effect over the sample is a direct algebraic estimation

NS not significant

* $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$

Table 16 Effect of doing a post-doctoral period early in the academic career for faculty recent scholarly output, by locality where the post-doctoral period was performed and regarding scholars aged between 31 and 42 years old

Variables	Sample mean	Abroad		UNAM		Other Mexican University	
		Post-doc effect	Post-doc effect/ sample mean (%)	Post-doc effect	Post-doc effect/ sample mean (%)	Post-doc effect	Post-doc effect/ sample mean (%)
Supervision undergraduate thesis	1.82	0.59	NS	0.07	NS	0.18	NS
Supervision master thesis	1.15	−0.15	NS	−0.11	NS	−0.38***	−33
Supervision PhD thesis	0.34	−0.001	NS	−0.0001***	0	0.001	NS
Articles	3.55	0.49	NS	0.09	NS	0.50	NS
Books	0.56	0.02	NS	0.01	NS	0.03	NS
Prototypes and patents	0.09	0.0001	NS	0.0001***	0	0.0001***	0

Results on the table are marginal effects from regression estimation reported on Table 9. The ratio of the post-doctoral period early in the academic career effect over the sample is a direct algebraic estimation

NS not significant

* $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$

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