What factors influence scientific and technological output: The case of Thailand and Malaysia[1]

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ABSTRACT

The paper aims to examine the factors that impact scientific outputs and technological outcomes in two Asian countries, Malaysia and Thailand. Using a survey instrument sent to young scientists in these two countries, we find that devoting a higher proportion of time to teaching, which we associate with career maturity, raising a greater proportion of research funds from international sources and collaborating more often at the national level are the main factors that influence research output. In addition, the survey shows that men are slightly more prolific than women in terms of research output, but the difference is not statistically significant. Moreover, once we account for a variety of factors that influence scientific production, our research does not give credence to the common argument that female researchers are less prolific, with one exception, however, women who have more children are less productive than their male counterparts.

INTRODUCTION

Becoming fully established as a member of the academic profession and pursuing access to a permanent position is a critical career goal for many young scientists and researchers all over the world. Their career paths, which is increasingly mobile and international, is also strongly shaped by local and national institutions and highly dependent on scientific production and impact. Several factors influence research performance, which ultimately contributes to building a research career. A number of these factors are socio-demographic, age and gender for instance, others are related to the choices made by the researchers, collaboration and funding spring to mind in this regard.

To get a better understanding of what obstacles and opportunities influence scientific production and thus shape young scientist careers, a questionnaire was sent to young scientists in Thailand and Malaysia. This short paper hence examines the factors identified in the survey

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that may be associated with a greater scientific and technological productivity. The next few paragraphs briefly survey the pertinent literature and propose hypotheses that will be further tested using appropriate regression models.

Age

The relationship between the age of researchers and their scientific productivity or scientific impact has been under scrutiny for a great number of years now (for a review of the topic, see Feist, 2006). Lehman (1953) demonstrated that major contributions are likely to occur when scientists are in their late 30s or early 40s, and thereafter decline rapidly. Since this seminal paper, the literature on the relationship between ageing and research productivity appears to be separated into two groups, each reporting opposite findings. Some claim that scientists conduct their best work while young (Einstein, Newton and Gauss are obvious examples), while others argue that know-ledge matures with age (Plank, Braun and Cram were in their 40s when they formulated their theories). The first group generally advocates that younger researchers are more productive and more likely to be cited than their older colleagues (Over, 1988) and that extraordinary achievements tend to occur before the age of 40 (Dietrich & Srinivasan, 2007). In contrast, the second group of studies argues that it is not the younger researchers, but the mid-career- and older researchers, who produce the most research and have a greater scientific impact. With this in mind, our first hypothesis proposes that:

H1 (Age): Older young scientists are more productive in terms of research output.

Gender

A vast literature highlights the poor research performance of women in relation to that of men. On average, women publish fewer papers than their male colleagues (Fox, 2005). Some scholars have, however, noted a narrowing of the gap in the publication differences between gender, as the population of female scientists increases (Abramo et al., 2009), and no gender effect on scientific productivity has been found for certain fields. In addition, women seem to be less productive in the first decade of their career, but are more productive afterwards (Long, 1992). A smaller proportion of women benefit from research funds, but both men and women receive grant amounts proportional to the number of submitted proposals at NIH and NSF (Fox, 1991). A number of explanations for these discrepancies have been put forward over the years. For instance, opportunities for women to collaborate are significantly less than those for men when women have young children and are therefore less mobile. Indeed, Larivière et al. (2013: 213) found that “female collaborations are more domestically oriented than are the collaborations of males from the same country”. It would therefore seem that childcare, the age of the children (Fox, 2005) and the lack of research collaboration are the main obstacles to increase productivity (Kyvik & Teigen, 1996). In fact, childcare affects the productivity of women but not that of men (MIT, 1999). Some scholars advance that there are broad gender inequalities regarding access to research funding and equipment. Women often work in universities with a lesser research intensity. Furthermore, women devote more time to teaching and administrative duties than men (DesRoches et al., 2010) and specialise less than men (Leahey, 2006). Our second hypothesis is therefore:

H2 (Gender): Female researchers are less prolific in terms of scientific output.

Funding

Some studies have shown that better-funded scientists are more frequently cited and more productive than less-funded scientists (Beaudry & Allaoui, 2012): the granting of research money further acts as a signal that attracts additional funding in subsequent years; research financing has a strong positive impact on the number of scientific articles published; and specific grants add one additional publication within the five years subsequent to the attribution of the grant (Jacob and Lefgren, 2007). Furthermore, industrial R&D contracts and funding from private sources have an impact if they represent a small proportion of total funding: "R&D contracts with industry and academic research activities have synergistic effects on scientific production, but only when R&D contracts account for a small percentage of a researcher"s total funding, otherwise, there are decreasing marginal returns to scientific output" (Manjarrés-Henríquez et al., 2009: 799). In this regard, other researchers found a positive effect of philanthropic funding coming from not-for-profit organisations. We propose that:

H3 (Funding): Researchers with a higher proportion of funding from (a) public national organisations will also generate more scientific output, while researchers with a higher proportion of funding from (b) private organisations or (c) philanthropic organisations will generate more technological output.

Collaboration

Networking and collaborating are both beneficial towards scientific production. In addition, collaboration can become a powerful lever to raise funds (Daniel et al., 2003), and consequently, scientific collaboration and research funding are intrinsically intertwined. Multi-project research centres encourage researchers and their universities to collaborate more efficiently, thereby leading to a more efficient use of the available diversity of resources of a physical, human and/or financial nature (Zucker et al., 2007). The fact that most papers are now written in collaboration may contribute to reducing the gender differences. Kyvik and Teigen (1996) identified the lack of research collaboration as one of the main obstacles to increasing research productivity. We would therefore expect collaboration to have a positive impact on research production, but that because women work in smaller or more localised teams their research may be less numerous. Our last hypothesis is therefore:

H4 (Collaboration): Researchers who collaborate will also generate more research output.

DATA AND METHODOLOGY

Data

The study is based on a questionnaire sent to all young researchers in Thailand and Malaysia, with a reminder two weeks later. Team members and colleagues[2] contacted the main research institutions of these countries, both public and private, in order to gain access to email lists of young researchers in these institutions. The questionnaire was launched in two phases using a convenience sampling technique; 218 responses were collected in April-June 2015, and 534 responses were collected in July-September 2015. This second wave of responses suffered from a significant respondent fatigue problem and thus resulted in only 325 valid responses. As a consequence, tests to compare the two samples were performed, but showed no significant differences between the two groups for the main variables of interest. Table A1 in the appendix describes the variables used in the model and a comparison between genders.

Model

We have identified two potential dependent variables: traditional research output measured by the number of articles, book chapters and conference presentations, as well as the number of

[2] Acknowledged in the first footnote.

pending and granted patents. These dependent variables being highly skewed, the empirical distribution is better represented by a log normal distribution. While the former follows a normal distribution once we have taken the natural logarithm of the variable, and can thus be analysed using Ordinary Least Squares (OLS), the latter comprises a significant number of zeros and has therefore been estimated using left-censored Tobit regressions. Once all missing values are accounted for, we are left with a sample of 338 observations on which the regression analysis was performed.

REGRESSION RESULTS

Table 1 presents the OLS regression results for the various factors that are associated with a higher number of articles, book chapters and conference presentations, while Table 2 presents the Tobit regression results on the number of patents[3]. During the course of our study, we compared „real" age with „PhD" age and chose the latter as yielding better and more robust results. As a standalone variable, neither variable was ever significant, which is not surprising considering the fact that our sample is composed mainly of young scientists. The effects that other scholars are measuring on vast cohorts or differently aged scientists are simply non-existent with a more homogeneous cohort. Only when interacted with gender and with the proportion of hours dedicated to various tasks (column Art-4), or with foreign collaboration (column Pat-12) was „PhD" age significant. As researchers age, only a higher proportion of time devoted to research tasks has a positive impact on scientific output, more time dedicated to teaching or to applying for grants has a negative effect.

Similarly, gender as a standalone variable is not significant. Gender, however, moderates the relationship between research output and „PhD"age, the number of children, the proportion of hours devoted to research, foreign collaboration, and mobility. As such, our research cannot say that female researchers are less prolific once we account for a variety of factors that influence scientific production. For instance, although young women produce fewer publications in their early career, our results suggest that as they grow older, they make up for this low performance (Figure 1 illustrates the results of column Art-10 in this regard). Congruently to what is generally found in the literature, women who have more children (column Art-2) are less productive than their male counterparts. Having children is, however, associated with a degree of maturity that we do not successfully capture with age. Our results show that men with children (column Art-3) are more productive, followed by women with children. Furthermore, female scientists who collaborate with foreign partners do not reduce their technological output, i.e. patents (column Pat-12) as much as men do when they collaborate with foreign colleagues.

Our funding variables only highlight the importance of private funding and of international funding for research output. Contrarily to most studies, we do not have access to the specific amounts of funding raised by individual researchers but only to the proportion of funding from each source. We would therefore not expect to replicate most results from the literature. Private and international funding matter more for classic research output (in Table 1). Surprisingly, private funding has no impact on technological output (in Table 2). For all four categories of output, however, international funding has a strong positive relationship. We therefore suggest that the funding model that brings consensus in the literature may not be

[3] Various transformations are used to normalise the variables: the natural logarithm for the two dependent variables and for the number of children, as well as the inverse for the proportion of the working hours and the funding variables.

appropriate for developing countries, which rely on international and philanthropic funding organisations.

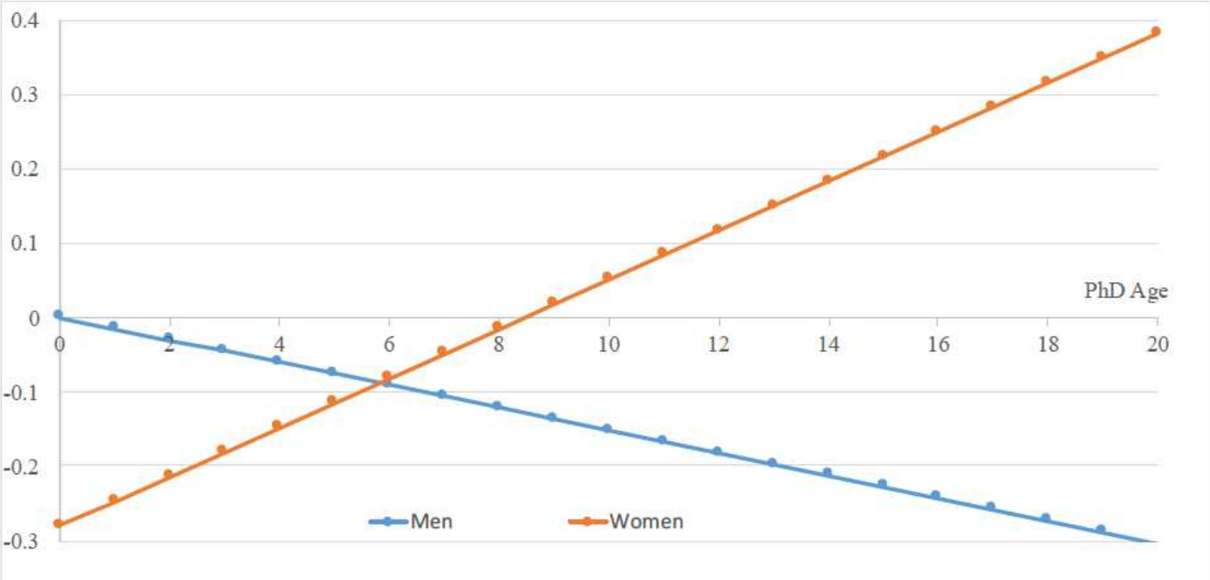

Figure 1. Impact of gender on scientific production (number of papers, book chapters and conference presentations) with respect to 'PhD' or career age

Finally, a higher frequency of collaboration is clearly associated with higher research productivity. Because of the importance of international funding, we included foreign collaboration in the regressions. This latter type of collaboration does not impact research productivity on its own but requires moderating effects from various other indicators to have an influence: for instance, the number of hours devoted to research or to fundraising (column Art-8), „PhD" age – or career maturity – (column Art-11), or even gender (column Art-11). These point towards a more complex framework to be able to fully capture the influence of such an indicator.

DISCUSSION AND CONCLUSIONS

In this paper, we set out to examine four hypotheses corresponding to four types of factors that should have an impact of research production. The first hypothesis, related to researchers" age, is only very partially supported, which is not surprising considering the fact that our sample is composed mainly of young scientists. Only when interacted with gender and with the proportion of hours dedicated to various tasks is „PhD" or career age significant.

The hypothesis that female researchers are less prolific is rejected once we account for a variety of factors that influence scientific production. Our hypothesis is only significant when a moderating variable is used. These variables are: „PhD" or career age, the number of children, the proportion of hours devoted to research or foreign collaboration. For instance, our results clearly show that older women improve their performance as they age.

Table 1. Regression results for the number of articles, chapters and conferences (OLS)

ln(nbArtChapConf+1)	(Art-1)	(Art-2)	(Art-3)	(Art-4)	(Art-5)	(Art-6)
dFemale	-0.0386	0.0787		-0.0566	-0.0481	-0.0324
	(0.0876)	(0.1082)		(0.0872)	(0.0874)	(0.0872)
PhDAge	-0.0036	-0.0035	-0.0036	-0.1506 **	0.1613 *	-0.4452 **
	(0.0098)	(0.0097)	(0.0098)	(0.0587)	(0.0861)	(0.2039)
ln(nbChildren+1)	0.2501 ***	0.3848 ***		0.2292 ***	0.2391 ***	0.2512 ***
	(0.0874)	(0.1139)		(0.0871)	(0.0872)	(0.0869)
1/(propHoursTeach+1)	-0.8918 *	-0.8682 *	-0.8632*	-1.8547 ***	-0.9640 *	-0.8696 *
	(0.4985)	(0.4968)	(0.5010)	(0.6233)	(0.4978)	(0.4957)
1/(*propHoursResearch*+1)	-0.0618	-0.0238	-0.0674	0.0941	0.9436	0.0238
	(0.4996)	(0.4981)	(0.5000)	(0.4991)	(0.7205)	(0.4982)
1/(*propHoursCons*+1)	0.1304	0.1170	0.1453	0.2351	0.0893	0.1565
	(0.5562)	(0.5542)	(0.5575)	(0.5530)	(0.5542)	(0.5531)
1/(propHoursFund+1)	-0.5100	-0.4511	-0.4336	-0.3456	-0.6276	-3.0631 **
	(0.7920)	(0.7897)	(0.7937)	(0.7879)	(0.7909)	(1.4165)
PropSelfHousework	0.0009	0.0013	0.0012	0.0015	0.0011	0.0010
	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0015)
1/(*FundNational*+1)	-0.1309	-0.1219	-0.1159	-0.1000	-0.1215	-0.1004
	(0.1089)	(0.1087)	(0.1097)	(0.1087)	(0.1086)	(0.1092)
1/(FundPrivate+1)	-0.2249 *	-0.2102 *	-0.2227*	-0.2100 *	-0.2120 *	-0.2295 *
	(0.1198)	(0.1196)	(0.1200)	(0.1189)	(0.1194)	(0.1191)
1/(*FundPhil*+1)	-0.0669	-0.0617	-0.0466	-0.1264	-0.0684	-0.0645
	(0.1730)	(0.1724)	(0.1730)	(0.1732)	(0.1723)	(0.1720)
1/(FundInt+1)	-0.4286 ***	-0.4345 ***	-0.4502***	-0.4384 ***	-0.4184 ***	-0.4146 ***
	(0.1280)	(0.1276)	(0.1273)	(0.1270)	(0.1276)	(0.1274)
dMobility	0.0182	0.0019	-0.0061	0.0423	0.0496	0.0503
	(0.0951)	(0.0951)	(0.0957)	(0.0948)	(0.0961)	(0.0957)
CollForeign	0.0543	0.0540	0.0642	0.0546	0.0509	0.0522
	(0.0470)	(0.0468)	(0.0472)	(0.0466)	(0.0469)	(0.0468)
CollNational	0.1717 ***	0.1736 ***	0.1632***	0.1714 ***	0.1789 ***	0.1749 ***
	(0.0609)	(0.0607)	(0.0611)	(0.0604)	(0.0608)	(0.0606)
dFemale x ln(nbChildren)		-0.2684 *				
		(0.1463)				
Men_with_children			0.3535***			
			(0.1360)			
ChildlessWomen			0.0209			
			(0.1129)			
Women_with_children			0.2261*			
			(0.1274)			
PhDAge x 1/(PropHoursTeach+1)				0.1951 **		
				(0.0770)		
PhDAge x 1/(PropHoursResearch+1)					-0.2140 *	
					(0.1110)	
PhDAge x 1/(PropHoursFund+1)						0.4639 **
						(0.2139)
Constant	3.3279 **	3.1318 **	3.1613**	3.6754 **	2.6969 *	5.6558 ***
	(1.4869)	(1.4852)	(1.5004)	(1.4807)	(1.5163)	(1.8270)
Country dummy variables	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Number of observations	338	338	338	338	338	338
Loglikelihood	-369.97	-368.18	-369.87	-366.57	-367.99	-367.48
F	9.960 ***	9.717 ***	9.470***	9.955 ***	9.744 ***	9.821 ***
R^2	0.3859	0.3924	0.3863	0.3981	0.3930	0.3949
Adjusted R^2	0.3472	0.3520	0.3455	0.3582	0.3527	0.3547

Notes: ***, **, * represent significance at the 1%, 5% and 10% levels respectively; Standard errors in parentheses.

Table 1. (Cont'd)

ln(nbArtChapConf+1)	(Art-7)	(Art-8)	(Art-9)	(Art-10)	(Art-11)	(Art-12)
dFemale	-0.0377	-0.0394	-0.0418	-0.2806 **	-0.0188	-0.0408
	(0.0878)	(0.0870)	(0.0877)	(0.1403)	(0.4048)	(0.0878)
PhDAge	-0.0035	-0.0038	-0.0038	-0.0152	0.0362	-0.0034
	(0.0098)	(0.0097)	(0.0098)	(0.0110)	(0.0579)	(0.0098)
dChildren						0.2723 ***
						(0.0988)
ln(*nbChildren*+1)	0.2506 ***	0.2523 ***	0.2545 ***	0.2367 ***	0.2498 ***	
	(0.0876)	(0.0868)	(0.0876)	(0.0871)	(0.0884)	
1/(*propHoursTeach*+1)	-0.8895 *	-0.8997 *	-0.8940 *	-0.9542 *	-0.9504 *	-0.9010 *
	(0.4993)	(0.4951)	(0.4987)	(0.4963)	(0.5026)	(0.4989)
1/(*propHoursResearch*+1)	0.1974	-0.0167	-0.0813	0.0337	-0.0085	-0.0862
	(1.0057)	(0.4965)	(0.5003)	(0.4984)	(0.5035)	(0.4993)
1/(*propHoursCons*+1)	0.1227	0.1159	0.0975	0.2128	0.1440	0.1333
	(0.5576)	(0.5524)	(0.5578)	(0.5541)	(0.5602)	(0.5571)
1/(*propHoursFund*+1)	-0.5362	-5.0942 **	-4.1358	-0.4823	-0.4973	-0.4650
	(0.7980)	(2.1293)	(4.3553)	(0.7873)	(0.7942)	(0.7925)
PropSelfHousework	0.0010	0.0011	0.0009	0.0011	0.0011	0.0010
	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0015)
1/(*FundNational*+1)	-0.1297	-0.1413	-0.1288	-0.1123	-0.1309	-0.1244
	(0.1092)	(0.1083)	(0.1090)	(0.1086)	(0.1092)	(0.1092)
1/(*FundPrivate*+1)	-0.2256 *	-0.2508 **	-0.2291 *	-0.2271 *	-0.2288 *	-0.2282 *
	(0.1200)	(0.1195)	(0.1199)	(0.1191)	(0.1208)	(0.1198)
1/(*FundPhil*+1)	-0.0681	-0.0924	-0.0536	-0.0938	-0.0894	-0.0497
	(0.1733)	(0.1722)	(0.1738)	(0.1724)	(0.1739)	(0.1729)
1/(*FundInt*+1)	-0.4333 ***	-0.4120 ***	-0.4130 ***	-0.4223 ***	-0.4477 ***	-0.4509 ***
	(0.1291)	(0.1273)	(0.1294)	(0.1273)	(0.1281)	(0.1272)
dMobility	0.0188	0.0212	0.0148	0.0598	0.0369	0.0040
	(0.0952)	(0.0944)	(0.0952)	(0.0964)	(0.0957)	(0.0949)
CollForeign	0.1324	-1.6375 **	0.0554	0.0543	0.1507 *	0.0623
	(0.2672)	(0.7317)	(0.0471)	(0.0467)	(0.0883)	(0.0471)
CollNational	0.1703 ***	0.1723 ***	-0.7713	0.1736 ***	0.1469	0.1651 ***
	(0.0612)	(0.0605)	(1.1154)	(0.0606)	(0.1123)	(0.0610)
CollForeign x 1/(*PropHoursResearch*+1)	-0.1111					
	(0.3741)					
***CollForeign* x 1/(*PropHoursFund*+1)**		1.7453 **				
		(0.7533)				
CollNational x 1/(*PropHoursFund*+1)			0.9636			
			(1.1382)			
dFemale* x *PhDAge				0.0483 **		
				(0.0220)		
dFemale x *CollForeign*					0.0535	
					(0.0868)	
dFemale x *CollNational*					-0.0440	
					(0.1177)	
PhDAge* x *CollForeign					-0.0254 **	
					(0.0118)	
PhDAge x *CollNational*					0.0091	
					(0.0155)	
Constant	3.1801 **	7.7838 ***	6.9253	3.2416 **	3.1425 **	3.3061 **
	(1.5700)	(2.4249)	(4.5021)	(1.4785)	(1.5483)	(1.4905)
Country dummy variables	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Number of observations	338	338	338	338	338	338
Loglikelihood	-369.92	-367.12	-369.59	-367.40	-367.08	-370.28
F	9.463 ***	9.872 ***	9.512 ***	9.831 ***	8.562 ***	9.914 ***
R^2	0.3860	0.3962	0.3873	0.3952	0.3963	0.3848
Adjusted R^2	0.3453	0.3560	0.3466	0.3550	0.3500	0.3460

Notes: ***, **, * represent significance at the 1%, 5% and 10% levels respectively; Standard errors in parentheses.

Table 2. Regression results for the number of patents (Tobit)

ln(nbPatents+1)	**(Pat-1)**	**(Pat-2)**	**(Pat-3)**	**(Pat-4)**	**(Pat-5)**	**(Pat-6)**	**(Pat-7)**
dFemale	-0.0905	-0.0378	-1.5940 **		-0.0927	-0.0938	-0.0895
	(0.1176)	(0.1480)	(0.7953)		(0.1179)	(0.1177)	(0.1177)
PhDAge	-0.0082	-0.0080	-0.0071	-0.0050	-0.0333	0.0633	-0.0678
	(0.0142)	(0.0142)	(0.0141)	(0.0141)	(0.0893)	(0.1214)	(0.2861)
ln(*nbChildren*+1)	0.0026	0.0612	0.0016	0.0327	0.0005	0.0001	0.0035
	(0.1171)	(0.1541)	(0.1167)	(0.1156)	(0.1173)	(0.1172)	(0.1172)
1/(propHoursTeach+1)	-1.5539 **	-1.5431 **	-1.5113 **	-1.6365 **	-1.7091 *	-1.5777 **	-1.5510 **
	(0.6805)	(0.6804)	(0.6783)	(0.6706)	(0.8704)	(0.6814)	(0.6806)
1/(*propHoursResearch*+1)	0.3290	0.3430	-0.6256	0.2598	0.3526	0.7691	0.3392
	(0.6871)	(0.6874)	(0.8489)	(0.6766)	(0.6919)	(1.0112)	(0.6889)
1/(*propHoursCons*+1)	1.1043	1.0966	1.0613	1.0808	1.1230	1.0920	1.1059
	(0.7877)	(0.7875)	(0.7886)	(0.7798)	(0.7904)	(0.7880)	(0.7877)
1/(*propHoursFund*+1)	-0.3549	-0.3317	-0.3001	-0.1396	-0.3358	-0.3981	-0.6848
	(1.0931)	(1.0943)	(1.0914)	(1.0833)	(1.0947)	(1.0956)	(1.9223)
PropSelfHousework	0.0007	0.0009	0.0011	0.0007	0.0008	0.0008	0.0007
	(0.0021)	(0.0021)	(0.0021)	(0.0020)	(0.0021)	(0.0021)	(0.0021)
1/(*FundNational*+1)	-0.1123	-0.1074	-0.1042	-0.1200	-0.1083	-0.1094	-0.1083
	(0.1478)	(0.1480)	(0.1473)	(0.1455)	(0.1485)	(0.1479)	(0.1490)
1/(*FundPrivate*+1)	-0.2026	-0.1968	-0.2265	-0.2138	-0.2004	-0.1983	-0.2033
	(0.1612)	(0.1615)	(0.1613)	(0.1589)	(0.1614)	(0.1613)	(0.1613)
1/(*FundPhil*+1)	0.0969	0.0967	0.0752	0.1630	0.0887	0.0954	0.0967
	(0.2398)	(0.2397)	(0.2397)	(0.2384)	(0.2415)	(0.2399)	(0.2399)
1/(FundInt+1)	-0.3458 **	-0.3497 **	-0.3372 **	-0.4005 **	-0.3471 **	-0.3398 **	-0.3427 **
	(0.1714)	(0.1715)	(0.1707)	(0.1697)	(0.1714)	(0.1716)	(0.1720)
dMobility	0.0068	-0.0003	-0.0059		0.0096	0.0181	0.0109
	(0.1262)	(0.1267)	(0.1260)		(0.1266)	(0.1276)	(0.1277)
CollForeign	-0.0158	-0.0159	-0.0122	-0.0231	-0.0157	-0.0172	-0.0161
	(0.0629)	(0.0629)	(0.0627)	(0.0619)	(0.0629)	(0.0629)	(0.0629)
CollNational	0.1955 **	0.1966 **	0.1835 **	0.2091 **	0.1954 **	0.1991 **	0.1966 **
	(0.0837)	(0.0837)	(0.0836)	(0.0825)	(0.0837)	(0.0840)	(0.0839)
dFemale x ln(*nbChildren*)		-0.1151					
		(0.1964)					
dFemale x 1/(PropHoursResearch+1)			2.0674 *				
			(1.0812)				
MobileMen				-0.4139 **			
				(0.1776)			
NonMobileWomen				-0.6204 ***			
				(0.1974)			
MobileWomen				-0.2397			
				(0.1772)			
PhDAge x 1/(*PropHoursTeach*+1)					0.0326		
					(0.1141)		
PhDAge x 1/(*PropHoursResearch*+1)						-0.0939	
						(0.1586)	
PhDAge x 1/(*PropHoursFund*+1)							0.0623
							(0.2988)
Constant	0.6790	0.5986	1.3738	0.9273	0.7431	0.3863	0.9804
	(2.0277)	(2.0322)	(2.0534)	(1.9992)	(2.0399)	(2.0858)	(2.4897)
Country dummy variables	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
sigma	0.9455 ***	0.9450 ***	0.9411 ***	0.9292 ***	0.9453 ***	0.9450 ***	0.9454 ***
	(0.0494)	(0.0493)	(0.0491)	(0.0484)	(0.0493)	(0.0493)	(0.0494)
Number of observations	338	338	338	338	338	338	338
Loglikelihood	-392.77	-392.60	-390.94	-387.26	-392.73	-392.59	-392.75
χ^2	133.833 ***	134.176 ***	137.5 ***	144.85 ***	133.915 ***	134.186 ***	133.876 ***
Pseudo R^2	0.1456	0.1459	0.1496	0.1575	0.1457	0.1460	0.1456

Notes: ***, **, * represent significance at the 1%, 5% and 10% levels respectively; Standard errors in parentheses. Number of left-censored observations = 118.

Table 2. (Cont'd)

ln(nbPatents+1)	(Pat-8)	(Pat-9)	(Pat-10)	(Pat-11)	(Pat-12)	(Pat-13)	(Pat-14)
dFemale	-0.0853	-0.0910	-0.0985	0.0686	-0.1910	-0.0911	
	(0.1165)	(0.1168)	(0.1169)	(0.1906)	(0.5505)	(0.1177)	
PhDAge	-0.0069	-0.0085	-0.0078	0.0002	-0.1880 **	-0.0084	-0.0084
	(0.0141)	(0.0141)	(0.0140)	(0.0158)	(0.0772)	(0.0142)	(0.0142)
dChildren						0.0126	
						(0.1344)	
ln(*nbChildren*+1)	0.0054	0.0060	0.0190	0.0117	0.0093		
	(0.1161)	(0.1164)	(0.1168)	(0.1173)	(0.1156)		
1/(*propHoursTeach*+1)	-1.5121 **	-1.5674 **	-1.5541 **	-1.5255 **	-1.1975 *	-1.5459 **	-1.5093 **
	(0.6734)	(0.6756)	(0.6759)	(0.6798)	(0.6691)	(0.6813)	(0.6837)
1/(*propHoursResearch*+1)	3.1516 **	0.4268	0.2773	0.2638	0.4761	0.3338	0.3484
	(1.3879)	(0.6836)	(0.6832)	(0.6887)	(0.6734)	(0.6862)	(0.6865)
1/(*propHoursCons*+1)	1.0087	1.0900	0.9960	1.0427	1.3935 *	1.1119	1.1227
	(0.7782)	(0.7818)	(0.7825)	(0.7883)	(0.7703)	(0.7886)	(0.7887)
1/(*propHoursFund*+1)	-0.6233	-6.7196 **	-11.4000 *	-0.3896	-0.0551	-0.3541	-0.3277
	(1.0891)	(2.9938)	(6.3234)	(1.0919)	(1.0724)	(1.0929)	(1.0944)
PropSelfHousework	0.0016	0.0010	0.0006	0.0007	0.0007	0.0008	0.0010
	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0020)	(0.0021)	(0.0021)
1/(*FundNational*+1)	-0.0993	-0.1237	-0.1029	-0.1208	-0.0673	-0.1115	-0.1023
	(0.1466)	(0.1470)	(0.1470)	(0.1477)	(0.1446)	(0.1480)	(0.1487)
1/(*FundPrivate*+1)	-0.2157	-0.2372	-0.2079	-0.2007	-0.1816	-0.2018	-0.1978
	(0.1598)	(0.1609)	(0.1603)	(0.1611)	(0.1582)	(0.1612)	(0.1612)
1/(*FundPhil*+1)	0.0880	0.0513	0.1564	0.1132	0.1299	0.0962	0.0971
	(0.2379)	(0.2391)	(0.2408)	(0.2399)	(0.2358)	(0.2393)	(0.2393)
1/(*FundInt*+1)	-0.3973 **	-0.3229 *	-0.3071 *	-0.3508 **	-0.3154 *	-0.3447 **	-0.3455 **
	(0.1714)	(0.1707)	(0.1716)	(0.1712)	(0.1671)	(0.1703)	(0.1702)
dMobility	0.0142	0.0130	0.0006	-0.0161	-0.0346	0.0067	-0.0027
	(0.1252)	(0.1253)	(0.1255)	(0.1279)	(0.1236)	(0.1259)	(0.1269)
CollForeign	0.8268 **	-2.4212 **	-0.0158	-0.0148	-0.4056 ***	-0.0155	-0.0138
	(0.3668)	(1.0636)	(0.0626)	(0.0628)	(0.1179)	(0.0630)	(0.0630)
CollNational	0.1806 **	0.1945 **	-2.6565 *	0.1920 **	0.2348	0.1954 **	0.1939 **
	(0.0830)	(0.0833)	(1.6082)	(0.0836)	(0.1492)	(0.0837)	(0.0837)
***CollForeign* x 1/(*PropHoursResearch*+1)**	-1.1926 **						
	(0.5115)						
***CollForeign* x 1/(*PropHoursFund*+1)**		2.4802 **					
		(1.0940)					
***CollNational* x 1/(*PropHoursFund*+1)**			2.9110 *				
			(1.6395)				
dFemale x *PhDAge*				-0.0322			
				(0.0304)			
dFemale* x *CollForeign					0.3010 ***		
					(0.1147)		
dFemale x *CollNational*					-0.1756		
					(0.1566)		
PhDAge* x *CollForeign					0.0498 ***		
					(0.0159)		
PhDAge x *CollNational*					0.0131		
					(0.0209)		
Men_with_children							0.0874
							(0.1852)
ChildlessWomen							-0.0329
							(0.1539)
Women_with_children							-0.0803
							(0.1724)
Constant	-0.9576	6.8228 **	11.6477 *	0.7685	0.5929	0.6535	0.5228
	(2.1260)	(3.3597)	(6.4887)	(2.0256)	(2.0553)	(2.0336)	(2.0456)
Country dummy variables	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*

sigma	0.9362 ***	0.9385 ***	0.9394 ***	0.9439 ***	0.9189 ***	0.9454 ***	0.9450 ***
	(0.0488)	(0.0490)	(0.0490)	(0.0493)	(0.0479)	(0.0494)	(0.0493)
Number of observations	338	338	338	338	338	338	338
Loglikelihood	-390.06	-390.08	-391.19	-392.21	-384.71	-392.77	-392.60
□2	139.244 ***	139.210 ***	137.002 ***	134.950 ***	149.958 ***	133.841 ***	134.185 ***
Pseudo R^2	0.1515	0.1514	0.1490	0.1468	0.1631	0.1456	0.1460

Notes: ***, **, * represent significance at the 1%, 5% and 10% levels respectively; Standard errors in parentheses. Number of left-censored observations = 118.

Our third hypothesis on funding variables only highlights the importance of private funding and of international funding for research output. Hypothesis H3a cannot be validated. Private and international funding matter more for classic research output. Surprisingly, private funding has no impact on technological output. We therefore cannot validate hypothesis H3b, nor H3c. For all four categories of output, however, international funding has a strong positive relationship with scientific output.

The last hypothesis is the only one that is wholeheartedly supported, hence validating the close relationship between collaboration and research output of any kind. A higher frequency of collaboration is clearly associated with higher research productivity. This goes beyond the scope of this paper but is a very promising avenue for research.

This research is based on a single survey on the perception of researchers about their career and research outputs. As such, there are a number of limitations to this study. First, out of the 750 responses, only 338 are usable for our regression analysis. We soon realised that the questionnaire was too long. This will have to be remedied in future similar studies. Second, the survey was entirely anonymous and as a consequence, we cannot verify the true output of these researchers using a standard bibliometric tool, but more importantly, the survey cannot be used to further study these researchers in the future to see whether their perceptions will have had an impact on their future career.

In terms of policy, the take-home message from this paper is clearly that the importance of foreign funding has an influence that is not noticed in developed countries that have well-developed grant-awarding organisations. Foreign collaboration and mobility also have a more complex impact that needs to be further investigated. These foreign relations are important and may compensate deficiencies in the local science system.

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