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Boosting Scientific Research: Evidence from a Public Program[§]

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ABSTRACT

We analyze the design of a unique Spanish public program aimed at recruiting high quality researchers in public research centers: the Ramón y Cajal Program. We claim that, after a number of calls, the program design changed in response to agents' needs. Exploiting data on applications and candidates we find that the new program design led to significant changes in the probability of being awarded with a contract. In particular, opportunities for candidates without attachment to the system were equalized.

Keywords: Brain Gain, Government Research Programs, Human Capital, Differences in Differences.

JEL Classifications: O38, D78, C21, C78.

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1 Introduction

The key role of human capital in economic development (see Galor (2005) for a recent survey) makes the design of incentives crucial for institutions concerned with human capital improvement, namely education and scientific research. This paper analyzes the design of the Ramón y Cajal Program, a policy measure promoted by the Spanish Government. The program was motivated by two pervasive problems: the shortage of budget resources and R&D personnel in Spanish centers, and the widespread practice of academic inbreeding. The shortage of funds undermined the development of a career path for junior researchers inside the system, who lack of an entry point into the R&D system. Also, both the lack of funds and the inbreeding practices impeded the access of new researchers to the research system.

The program was aimed at financing top and promising researchers, subject to rigorous and objective selection criteria, allowing them to join Spanish research centers and providing then with a well defined career path.[1] The selected candidates would receive a 5-year contract in a Spanish research center, as well as a somewhat formal priority in their choices of research in accordance with their relative position in the ranking. Afterwards, the research centers involved would receive a subsidy of 80 percent of the researcher's salary for the 5-year period, paid during each of the years in a decreasing scheme.[2]

[1] See Sanz Menéndez et al. (2002) and Sanz Menéndez (2003), for an account of the institutional background.

[2] As a measure of the importance of the program, the number of grants offered were 800

A key feature of the program in its first two calls was that for a researcher to qualify, she needed an endorsement by a research center, that is, a formal commitment by the center that it would hire the researcher if she was appointed by the program. This requirement was relaxed in the third call, so that endorsement became optional, although selected candidates with endorsement retained priority in the centers that had endorsed them. From the fourth call, endorsement was completely removed.

Shortly after the program was launched, there existed a substantial stock of junior candidates within the research centers. Under the original design, research centers beared the costs of screening for suitable candidates through the endorsement process. After a few number of calls, though, the stock of candidates within the centers became exhausted and centers were forced to seek for external candidates. This circumstance soar their cost of searching for suitable candidates.

The change in the design removed the endorsement requirement and switched from a decentralized to a centralized procedure of candidate selection. After the policy change, candidates applied directly to the governmental agency, and the match between candidates and centers was done after the candidates eligible for contracts had been selected.

We are intrigued by the extent to which the original design of the program, jeopardizing eligibility of candidates external to the system, affected

in 2001, when the first call was launched, and 500, 700 and 300 in the subsequent calls, from 2002 to 2004, respectively. These grants jointly amounted to 365 million Euro to be financed by the Government.

the odds of such candidates. For this purpose, we exploit applications' data on the four first calls to empirically analyze the design change and the role of endorsement in candidates' opportunities. We posit that the key change in the program design, removing the endorsement requirement, equalized the opportunities for candidates without attachment to the system.

The remainder of the paper is organized as follows. Section 2 describes the Ramón y Cajal Program. In Section 3, we introduce the data and provide a descriptive evidence related with the first four calls of the Program. Section 4 approaches a policy analysis based on applications and candidates' data, and Section 5 concludes.

2 The Ramón y Cajal Program

The Program was established by the Spanish Government in the general context of a lack of R&D personnel in Spain and with Spanish Universities hiring policies being called into question. The latter issue generated lively debate that was reflected in the international press and scientific journals. The two main issues were: (i) the lack of sufficient funding and (ii) the existence of social networks that, regardless of candidates' scientific merits, systematically hire one of their members (Navarro and Rivero, 2001). Inbreeding has a long tradition in Spain. Its existence has been linked to poor scientific performance (see, for instance, Eisenberg and Wells, 2000; Soler, 2001). In addition, Spanish academia suffers from hostility towards researchers who have completed their training abroad (Ferrer, 2000).

To encourage hiring of R&D personnel in research centers while circumventing the aforementioned distortions, the Spanish Government implemented the Ramón y Cajal Program. This program provided funding for 5-year contracts in research centers for the selected researchers. The selection procedure was centralized in an evaluation agency, Agencia Nacional de Evaluación y Prospectiva (ANEP). This evaluation agency, appointed by the Government, appraised all eligible applicants based on rigorous and objective evaluation criteria (mainly, scientific contributions), so that the better the researcher, the higher should be their priority to choose available positions. For this purpose, 24 evaluation committees of national and international experts, one for each research field, were constituted by the evaluation agency.[3] Overall, 341 experts took part in the evaluation in every call. If a contract was granted to a researcher, she could join any of the research departments that had endorsed her. The objective was two-fold: (i) to provide incentives to research centers to hire top researchers and (ii) to encourage top researchers to join Spanish research centers.

When the Program was started, there were a large number of junior insiders –researchers already in the system– under temporary positions. Most of them had a low probability of obtaining a stable contract within the Spanish R&D system, mainly because of a lack of funding. To provide them an entry point into the Spanish R&D system was among the political objectives of the program. In this context, the empirical evidence regarding the first call

[3] A list of the 24 research areas is shown in the Appendix, Table A1.

shown in Table 1 is clear. Among the applicants who obtained a contract in 2001, sixty percent were insiders, that is, researchers already in the system.

The original design of the Program, requiring each candidate to seek endorsement by at least a research center, was maintained for the first three calls. In the first three calls, each candidate was required a Ph.D. degree and a postgraduate stay of at least 18 months in a research center different to her Ph.D.'s. In 2003, a key modification altered the eligibility conditions, making endorsement optional, and endorsement was completely removed since 2004. However, while endorsement was removed, other requirements became more stringent. Since then, each candidate was required to earn her Ph.D. in the last 10 years,[4] and a postdoctoral stay of at least 24 months in a research center different to her Ph.D.'s.

The original design not only prioritize insiders but also jeopardized the eligibility of external candidates. Later, when the stock of high quality insider candidates declined,[5] the design was no longer useful and it was then reformed. Also, the tighter requirements imposed since 2004 undermined insiders' chances in the Program,[6] jeopardizing eligibility and weakening the implicit contracts between research centers and their insiders.

[4] Maternity leave, military service or major illness were excluded from the time computation.

[5] The number of insider applicants tended to decrease for several reasons. Some were excluded from the pool of potential applicants either because they were selected and obtained a contract in an earlier call or because they lost eligibility in subsequent calls.

[6] At the same time, the Juan de la Cierva program was developed for researchers about to present their doctoral dissertation or having done so in the last 3 years.

3 Data and preliminary evidence

To assess the consequences of the design changes in the Ramón y Cajal Program, we exploit data about several calls of the Program provided by the Dirección General de Investigación of the Spanish Ministry of Education. Data on researcher applications and information provided by the 125 research institutions that participated in the program in four annual calls between 2001 and 2004, were used. We excluded observations with missing values for individual characteristics, which represent less than one percent of all observations. Most participant institutions have more than one research department among the 24 research areas into which the applicants were divided.

Our data set is composed of 10895 applications from 2001 to 2004, corresponding to 6146 researchers. There are more applications than candidates, since researchers can apply several times, for two non-exclusive reasons: i) they do not achieve a contract in a given year and they decide to apply again in a subsequent call, ii) they apply in a given year in two or more different research areas, thus accounting for different applications in that call.

The curricular information for the individuals at the time of the call was collected from the free software program *Publish or Perish* (Harzing, 2007) in combination with the *Journal of Citation Reports* (JCR).[7] This software retrieves academic contributions by author using information from Google

[7] We merged data from applications and applicants' publication records according to the name and surname of the applicant, as well as her affiliation and research area.

Scholar, which provides the title, the source, the year and the authors of the contribution. Whenever the contribution was published in a scientific journal, the journal information is also reported. We have also retrieved the impact factor from the JCR in order to weight the quality of each individual's contribution. We define the average impact factor of her JCR contributions as the ratio of the cumulated impact factor to the number of publications up to the year of the call. A researcher without contributions published in a journal listed in the JCR will trivially have a zero average impact factor.

The distribution of applications and candidates in the first four calls is shown in Table 2. The total number of applications and candidates exhibited a sharp decrease in 2004. This fact coincided with a sharp reduction in the number of contracts offered, and with the design change, which affected eligibility requirements. Unlike the subsequent calls, the first call shows the distinguishing feature that most candidates had a single application. We partly attribute this feature to the existence of a sizeable stock of insiders in the Spanish R&D system when the program was launched. The insiders in 2001 are most likely to apply only once, to the center to which they were attached. The same feature can be seen in Table 3, which shows the number of endorsements per candidate.

Table 4 shows the distribution of candidates in each call according to the number of previous calls in which they participated. Remarkably, a significant proportion of previously unsuccessful candidates applied again in later calls, as shown in the upper panel. Since 2002, at least 43% of the applicants had applied in a previous call. More specifically, the proportion of new applicants in each call, i.e., those that had not applied before, is around 57% in 2002, 55% en 2003 and only 40% in 2004. We also report the number of granted candidates and the relative frequencies of successful candidates. For those candidates with previous applications, the probability of receiving a grant remains at moderately high values.

In Table 5 we have broken down the candidates in 2003 regarding whether they had endorsement or not. The percentage of granted candidates is higher for those with endorsement, with a difference of 11 percentage points. In the lower panel, we have broken down 2004 candidates, regarding whether they had also applied or not in 2003. If we concentrate on those who had also applied in 2003, we observe that the difference in the success probability between those with and without endorsement is now negative.

4 Policy analysis

The change in application requirements, with endorsement completely removed in 2004, provides a natural experiment under which certain individuals are affected by the policy change. In particular, we can compare the outcomes in 2004 and 2003 for applicants with and without endorsement. Our approach simply consists of a differences-in-differences (DID) estimator. The estimation sample is composed of all the applications in 2003 and 2004. While some individuals only applied at one of the two calls, other ones applied in both calls (none of them had a contract in 2003).

We denote i for application and s for the year of the call (2003 or 2004). Let D_{is} be a binary variable that equals one if the application corresponds to an individual who applied *without endorsement* in 2003, and zero otherwise.[8] Also, let T_{is} be a binary variable that equals one for applications in 2004, after the policy change, and zero for applications in 2003. Our outcome variable, Y_{is}, is a binary indicator that equals 1 if the application is granted and 0 otherwise. The vector X_{is} contains some individual characteristics that will be detailed below. To analyze the effect of the change in the endorsement requirement, we consider the model for the probability of success, defined as being granted a contract:

$$\Pr\left(Y_{is} = 1 \middle| T_{is}, D_{is}, X_{is}\right) = \beta_0 + \delta_0 T_{is} + \beta_1 D_{is} + \delta_1 T_{is} \times D_{is} + X_{is}' \gamma \quad (1)$$

The critical coefficient is δ_1, which measures the average effect of the policy. It can be seen (Wooldridge, 2002) that δ_1 captures the difference between the average change in outcome between 2003 and 2004 for individuals affected by the policy rule and the corresponding change for the remaining individuals.

To estimate (1), we consider a linear probability model. In contrast with the logit or probit model, estimation is distribution-free. Its main limitation is that predicted probabilities are not guaranteed to be in the [0,1] interval. However, our interest is not on the estimated probabilities, but on the average partial effects, for which the linear probability model provides a good approximation. To see a discussion on this issue as well as some empiri-

[8] Therefore, D_i will take on value one for (i) individuals applying in 2003 without endorsement; and (ii) individuals who only applied in 2004.

cal applications in different contexts, see, for example, Angrist and Pischke (2009).

The validity of the simple specification in (1) requires that the only source of mean variation is the policy change. To control for unobserved individual differences not attributable to the policy change, we add different controls.

First, regarding the individual's curricular information, we use the average impact factor of her contributions published in JCR journals at the time of the call. To control for the heterogeneity of this quality measure across different research fields, we have considered its interaction with 7 research areas, in accordance with the classification used in *Publish or Perish,* instead of the 24 ANEP areas.[9]

Second, we also control for the quality of the center in which the candidate earned her Ph.D. The variable used is the scientific impact of the center, measured as the average number of citations to all the contributions published in JCR journals by its members. This information is available from the JCR.

Third, we have also considered some individual characteristics, such as gender and a second order polynomial in the years elapsed since the Ph.D. was obtained, and binary dummies for the place of residence of the candidate at the time of application. For residence, we have considered the following groups of countries: Spain, EU-15, Europe (others), US-Canada, America (others), Other countries.

Finally, we have also considered differential effects across areas and by

[9] A list of these areas is shown in the Appendix, Table A2.

call. We have considered a set of binary variables for the 24 research areas defined by the ANEP, and interact the variables with a binary variable for 2004.

The estimation results are shown in Table 6. Since, as mentioned earlier, some applications correspond to the same applicant, we have used clustered standard errors. To assess the robustness of the results, we have considered two different specifications, the simplest one without additional control variables in column (i) and a richer specification with the aforementioned control variables in column (ii).

The estimates for the policy parameter are very similar in both columns, in magnitude and significance. Our estimates imply that individuals who applied without endorsement in 2003 experienced an increase of 10 percentage points in their success probability after the endorsement removal in 2004, with respect to the remaining individuals. The results in column (ii) are conditional on covariates controlling for curricular characteristics. Therefore, we can assert that individuals applying without endorsement in 2003 have on average a success probability that is 10 percentage points higher than the remaining individuals with similar curricular and individual characteristics.

Regarding the control variables in column (ii), we observe that the individual's academic quality, measured by the average impact of her contributions, has a positive effect, but it is only significant in a few areas (Biology, Chemistry and Engineering). Also, the quality of the center where the candidate earned her Ph.D. exhibits a significantly positive effect, seeming to be a factor acknowledged by the assessment committees. We also find that, other things equal, male candidates exhibit a higher probability of being granted.

In the 2004 call, two further requirements were introduced. First, the number of years elapsed after obtaining the Ph.D. was limited to a maximum of 10. Second, applicants should prove a postdoctoral stay of 24 months in a research center different to her Ph.D.'s. Our data do not allow us to control for the second requirement, but we can control for the first one. We also report, in columns (iii) and (iv), estimates for the subsample of applicants who achieved their Ph.D. in the last 10 years. The qualitative and quantitative results remain similar to the full sample results.

For the sake of clarity, we have reported in Table 7 the components of the DID estimator corresponding to the estimates in Table 6. In the second row, we have measured the estimated average difference in the success probability in 2003 between those without and with endorsement, which is about -9 percentage points, even controlling for their academic performance and other control variables. When we consider the individual's success probability in 2004 (in the first row), however, there are not differences with respect to her previous endorsement status, which is exactly what we would expect, since endorsement was completely removed in the 2004 call. The DID effect (reported in Table 6 as the coefficient of the policy parameter) can be obtained as the difference between the first and the second row estimates. Such DID effect is clearly positive and significant.

Thus, our results show that, in 2003, endorsement played a relevant role to explain the probability of been granted a contract, even after controlling for academic quality of the applicants. However, once the endorsement was removed in 2004, individuals' odds became independent of their previous endorsement status. As a consequence, we can conclude that, for similar curricular and individual characteristics, the old mechanism limited the opportunities for those individuals with more difficulties to be endorsed.

5 Conclusions

The Ramón y Cajal Program was created to ameliorate the shortage of funds for research personnel and to improve the quality of the Spanish R&D system. For that purpose, the program provided funding to recruit quality researchers and to provide them an entry point into the R&D system. When the program was started, there existed a substantial stock of insider junior researchers within the centers, who lack of a career path because of the shortage of funds.

Apparently, this fact determined the original design of the program, by which only candidates with endorsement from at least one research center were eligible to receive a contract. This design led the costs of selecting candidates to be beared by the centers. Such costs remained low as long as the stock of suitable insider candidates was large enough, but soared when centers run out of suitable insider candidates and had to seek for external candidates. At that time, the program was redesigned, making endorsement optional in the third call and removing it in the fourth call. Also, the selection of candidates was centralized under the governmental agency. This meant, on one side, that research centers no longer beared the cost of screening candidates, and, on the other side, that any potential candidate could participate in the Program.

The new design, with the complete removal of the endorsement, represents an improvement over the original one. Unlike the original design, the new design equalizes the odds of potential candidates, irrespective of their degree of attachment to research centers. The mechanism ensures that the overall quality of the applicants selected is improved by precluding the exclusion of any candidate. Also, the selection costs are internalized by the system.

We analyzed the effect of the changes in the program design on the probability of earning a contract by exploiting applications' data for the 2003 and 2004 calls. The availability of data on researchers who applied in 2003, under the optional endorsement scheme, and applied again in 2004, when endorsement was removed, provided a natural experiment, which enables to assess whether endorsement status actually affected candidates' opportunities.

We find that, in 2003, endorsement status increased candidate's chances, even after controlling for her academic quality. On the contrary, in 2004, when endorsement disappeared, the success candidate's probability became independent of her earlier endorsement status. Thus, our empirical results reveal that the prioritization of insider candidates had the cost to exclude potentially better candidates from the program. The full removal of the endorsement equalized the opportunities for researchers for whom the old mechanism proved detrimental.

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Table 1
Final Distribution of Ramón y Cajal Contracts in the first call

Insiders	
All	60%
Outsiders	
Non-resident	14%
Resident	26%
All	40%

Note: Insiders (outsiders) are researchers who have (have not) a previous attachment with the center that endorses them.
(Source: DGI, MCYT from Sanz Menéndez et al., 2002)

Table 2
Applications and candidates by call in the first four calls

	2001	2002	2003	2004
Applications	2871	2957	3290	1777
Candidates	2789	2506	2550	1342
% candidates with several applications	2.5	18.0	29.0	32.4
Grants	782	497	700	297
% of granted applications	27.2	16.8	21.3	16.7
% of granted candidates	28.0	19.8	27.5	22.1

Table 3
Endorsements by candidate in each call

Number of endorsements	2001[a]	2002[a]	2003[b]	2004[c]
0	–	–	286 (11%)	1342
1	2037 (73%)	1671 (67%)	1456 (57%)	–
2	523 (19%)	620 (25%)	594 (23%)	–
3 or more	229 (8%)	215 (8%)	214 (9%)	–
Total number of candidates	2789	2506	2550	1342

[a]In 2001 and 2002 the endorsement was mandatory.
[b]In 2003 the endorsement was optional.
[c]In 2004 the endorsement was completely removed.

Table 4
Candidates by call and by number of previous calls

Number of previous calls				
	Total			
	2001	2002	2003	2004
0	2789	1434	1390	533
1		1072	612	405
2			548	233
3				171
	Granted candidates			
	2001	2002	2003	2004
0	782	297	370	120
1		200	158	91
2			172	59
3				27
	% of granted candidates			
	2001	2002	2003	2004
0	28.0	20.7	26.6	22.5
1		18.7	25.8	22.5
2			31.4	25.3
3				15.8

Table 5
Characteristics of applicants in 2003 and 2004

Applicants in 2003

	Number	Granted	% Granted
All	2550	700	27.5
With endorsement	2264	650	28.7
w/o endorsement	286	50	17.5

Applicants in 2004

	Number	Granted	% Granted
All	1342	297	22.1
Did not apply in 2003	649	142	21.9
Also applied in 2003	693	155	22.4
With endorsement	625	137	21.9
w/o endorsement	68	18	26.5

Table 6
Probability of obtaining a contract (Linear probability model)

	Full sample				Restricted sample[a]			
	(i)		(ii)		(iii)		(iv)	
Research area[b]	No		Yes		No		Yes	
Residence zone[c]	No		Yes		No		Yes	
const	0.222§	(0.007)	0.017	(0.042)	0.222§	(0.008)	-0.023	(0.048)
T	-0.067§	(0.014)	0.085	(0.076)	-0.064§	(0.014)	0.142*	(0.083)
D	-0.087§	(0.019)	-0.100§	(0.012)	-0.081§	(0.021)	-0.090§	(0.021)
$T \times D$	0.109§	(0.025)	0.103§	(0.026)	0.102§	(0.027)	0.090§	(0.027)
Avg. impact factor								
Biology			0.013§	(0.005)			0.011§	(0.005)
Business			-0.030	(0.047)			-0.029	(0.054)
Chemistry			0.017‡	(0.008)			0.019‡	(0.009)
Engineering			0.082§	(0.017)			0.077§	(0.016)
Medicine			0.009	(0.006)			0.009	(0.007)
Physics			0.024	(0.017)			0.024	(0.018)
Social Sc.			0.006	(0.007)			0.005	(0.007)
PhD center quality			0.007§	(0.002)			0.006§	(0.002)
Male			0.036‡	(0.014)			0.037‡	(0.015)
PhD tenure			0.019§	(0.004)			0.043§	(0.011)
PhD tenure^2			-0.0007§	(0.0002)			-0.003§	(0.001)
No. observations	5067		4667		4707		4365	

Wald Tests of Joint Significance (% p-value)

All variables	342.36	(0.00)	18.35	(0.00)	317.44	(0.00)	17.21	(0.00)
CV variables			6.12	(0.00)			5.67	(0.00)
PhD tenure			13.46	(0.00)			20.53	(0.00)
Research area			2.53	(0.00)			2.34	(0.00)
Residence zone			7.97	(0.00)			5.76	(0.00)
Interactions			1.69	(0.51)			1.72	(0.36)

Notes to Table 6:
§, ‡, and * denote 1, 5 and 10 percent significance. Clustered standard errors in parentheses.
[a]Only researchers who obtained the Ph.D. within the 10 years previous to the call
[b]The list of research areas in shown in the Appendix, Table A1
[c]Residence zones: Spain, EU-15, Europe (others), US-Canada, America (others), Other countries

Table 7
DID components

	Full sample				Restricted sample[a]			
	(i)		(ii)		(iii)		(iv)	
	Without vs. with endorsement		Without vs. with endorsement		Without vs with. endorsement		Without vs. with endorsement	
Diff. in 2004	0.023	(0.017)	0.003	(0.018)	0.022	(0.017)	-0.0002	(0.018)
Diff. in 2003	-0.087§	(0.019)	-0.100§	(0.012)	-0.081§	(0.021)	-0.090§	(0.021)
DID	0.109§	(0.025)	0.103§	(0.026)	0.102§	(0.027)	0.090§	(0.027)

See Notes to Table 6.

Table A1
Research areas (ANEP)

Physics and Space Sciences
Earth Sciences
Materials Science and Technology
Chemistry
Chemical Technology
Plant and Animal Biology. Ecology
Agriculture
Livestock and Fishery
Food Science and Technology
Molecular and Cell Biology and Genetics
Physiology and Pharmacology
Medicine
Mechanical, Ship and Aeronautical Engineering
Electrical and Electronic Eng. and Robotics
Civil Engineering and Architecture
Mathematics
Computer Sciences
Information and Communication Technologies
Economics
Law
Social Sciences
Psychology and Education Sciences
Philology and Philosophy
History and Art

Table A2
Research areas (Publish or Perish)

Biology, Life Sciences, Environmental Science
Business, Administration, Finance, Economics
Chemistry and Materials Science
Engineering, Computer Science, Mathematics
Medicine, Pharmacology, Veterinary Science
Physics, Astronomy, Planetary Science
Social Sciences, Arts, Humanities