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Article

The impact of subsidies on researcher's productivity: Evidence from a developing country

Diego Aboal[1,2,3,*] and Ezequiel Tacsir[1,4]

[1]Centro de Investigaciones Económicas (CINVE), Uruguay 1242, 11100 Montevideo, Uruguay, [2]Universidad ORT Uruguay, Bvar. España 2633, 11300 Montevideo, Uruguay, [3]Facultad de Ciencias Económicas y Administración, Universidad de la República, Gonzalo Ramirez 1926, 11200 Montevideo, Uruguay and [4]UNU-MERIT, Boschstraat 24, 6211 AX, Maastricht, The Netherlands

*Corresponding author. Email: aboal@cinve.org.uy

Abstract

In this article we perform an impact evaluation of a programme that provides ex post subsidies to researchers in Paraguay. The analysis spans across the first 2 years following the programme (short-run). Ex post subsidies are prevalent in Latin America; however, the analysis of their effects has received little attention in the literature. Thanks to the availability of data coming from electronic CVs of applicants, we are able to analyse the impact of the programme through dimensions of researchers' productivity that have been mostly overlooked previously. For example, we are able to use technical production, own education, other researchers' training, and other dimensions of the bibliographic production that are different to published articles. We also provide impact estimations on quantity and quality of publications based on more traditional sources of data. We find some positive impacts of the programme. However, some of the results are not robust to alternative methods of estimation.

Key words: economics of science; scientific subsidies; researchers' performance; policy impact evaluation.

1. Introduction

Since the seminal works by Nelson (1959) and Arrow (1962), knowledge has been regarded as a public good. As such, economic theory predicts that there will be an underinvestment in scientific research if left to the market alone. Therefore, throughout the world, governments devote considerable resources to scientific research.

Different allocation mechanisms have been put in place to do it. Generally speaking, research funding is done in three different ways: (1) long-term funding (or 'block funding') of research institutions, provided either completely or partially, and independently of research performance or outputs; (2) ex ante funding, in which money is provided in advance to pre-screened research projects or researchers that are all selected via a competition for grants; and (3) ex post funding, in which money is paid in retrospect on the basis of measurable research performance. The chosen mechanism is not neutral in its effects, in terms of both research scope and scientists career paths. Hence, it is understandable that this has been a recurrent topic in the science policy literature (see David, Hall and Toole 2000, Aghion et al. 2010, and Stephan 2010, to name a few of these contributions).

The fixed funding contract is in most cases a combination of ex post and ex ante contracts in which the contract specifies which proportion is independent of research performance. As such, the research subjects' selection decision falls on the research organizations themselves, with less monitoring by the funder. It is generally stated that long-term funding tends to stimulate riskier projects that are difficult to support if the system is to be entirely based on measurable and verifiable outputs in a given period of time.

On the other hand, ex ante mechanisms allow funders to control what (research projects) and/or who (researchers) is to be supported. In relation to the grants for pre-screened projects, governments are capable of selecting the most promising research ideas (assuming they have the capabilities to do so). Given that ex ante funding of projects provides weak monetary incentives to actually get to a verifiable research output, the typical financial instrument in this case is the matching grant. The research grant never covers all expected costs of selected projects (Crespi et al. 2011); in most of the cases, competitive funding covers input and research support costs but typically includes little to no support for the compensation of the principal researcher, which tends to be covered by some form of block funding.

The last mechanism tends to emphasize the provision of funds to be used as compensation to researchers. With ex post funding, governments provide a strong incentive to produce measurable output. Researchers are closely monitored in terms of their past production, which, in turn, might affect their likelihood of being funded in the future. Researchers are chosen based on their capabilities to conduct research (proxied by evidence of previous publications, technical products, or previously secure funding) and are generally offered support for a limited period of time (a few years), after which they are required to apply again to obtain support. As such, the funding agencies trust in the good judgment of productive researchers in terms of the selection of ideas and projects.

Obviously, each incentive scheme requires different institutional capacities to secure a successful implementation, implying that some mechanisms might result ill-suited for countries with little research and/or institutional capacity. In the first two settings, the funding agency should have the ability to review and assess either institutions and/or researchers based on how likely they will obtain the promised output. In the case of block funding, grant agencies should have a detailed account of the resources (human and infrastructure) available for research and how well aligned individual and institutional incentives are. In many developing countries, there is a dearth of infrastructure; no standardized indicators of research personnel and universities tend to focus on teaching rather than performing research.

For ex ante grants, the funding agency requires the services of well-reputed researchers who would be used as peer reviewers. Although this experience tends to be easily available in developed countries, it is a scarce asset in many developing countries, characterized by small research communities, with potential conflicts of interests and with research trajectories that might be very different from the selected topics. To mitigate these problems, funding agencies are forced to recruit peer reviewers from other countries, increasing the cost and time of the selection process.

Ex post funding requires either having the capacity to monitor research outputs that are considered relevant for the funding agency, or requesting this information to the researchers themselves. Generally, this last group of incentives tends to be implemented by developing countries. The aim is to provide an incentive that allows university personnel to devote a larger proportion of their time to research, rather than to other activities such as teaching or consultancy.

The objective of this article is to perform an impact evaluation of the National Programme of Research Support (Programa Nacional de Incentivo a los Investigadores, PRONII) of Paraguay, in terms of its impact on research output productivity since its first implementation in 2011. PRONII aims at strengthening and expanding the country's research community by establishing a process of voluntary participation in regular calls in which researchers are assessed in terms of their past production (their electronic CVs being the main tool in the selection of successful applicants[1]). Individuals meeting the basic criteria are categorized in one of four different categories. This type of subsidies can be understood as ex post subsidies. Nowadays, PRONII supports 386 researchers, out of a total of approximately 1,550 researchers in the country, of which only half are believed to be active (CONACYT 2012).

Our study provides two main contributions to the literature. First, we expand the evidence by evaluating econometrically the impact of a programme that provides ex post financial incentives to individuals (rather than to projects or institutions) to pursue their research activities. This type of incentives is pervasive in Latin America. In the recent period a growing literature on the effects of grants on academic careers has developed. However, the majority of this literature has focused on developed countries and on the role that other types of grants have had on the productivity effect in terms of publications and citations. Secondly, we exploit a new type of data source for our analysis, electronic CVs, and combine it with data on publications. Researchers' output can be classified in three categories: (1) bibliographic production, (2) advanced human capital, and (3) technical output. While previous literature has focused mostly on the first one, we are able to analyse the impact of the ex post subsidies to researchers on the three types of outputs.

The remainder of the article is organized in sections. Section 2 presents the received literature. Section 3 describes PRONII, its objectives, and the main eligibility criteria and selection procedures. Section 4 describes the data used in this evaluation. Section 5 focuses on describing the empirical strategy. Section 6 presents the impact evaluation results. Section 7 shows a cost-effectiveness analysis. Finally, Section 8 offers some conclusions.

2. Literature

Over the past two decades an empirical literature dealing with the impact of financial support on research productivity and careers has emerged. The majority of these contributions employ quasi-experimental methods to investigate the effects in terms of publications and citations, generally referring to these dimensions as quantity and quality.

The bulk of these contributions focuses on unveiling the impact of individual grants on academic careers in developed countries. This literature tends to emphasize that grantees do only marginally better in terms of productivity (Averch 1987; Godin 2002; Holbrook 2005, Arora and Gambardella 2005; Jacob and Lefgren 2011; Lanser and Van Dalen 2013). Jacob and Lefgren (2011), for example, estimate a causal impact of grant funding on publications. Contributions focusing on the impact of receiving a grant on individual careers are sparser but have been recently increasing. Specifically, a number of evaluative studies (Langfeldt and Solum 2007; Böhmer, Hornbostel and Meuser 2008; Böhmer and Hornbostel 2009; Böhmer and Ins 2009; Van Arensbergen and van den Besselaar 2012; Gerritsen, Plug and van der Wiel 2013; Van Arensbergen 2014; Huber, Wegner and Neufeld 2015) address the overarching question of the role that highly prestigious funding programmes play in the career development of young researchers, and provide empirical evidence about the impact of these programmes. Overall, these evaluative studies show a positive impact on the likelihood of successfully pursuing an academic career—that is, retaining talented young researchers in academia, increasing the probability of obtaining a professorship or receiving a follow-up research grant.

Nevertheless, this type of robust empirical evidence is rather absent for developing countries. For instance, Fedderke and Goldschmidt (2015) evaluate whether a substantial increase in public funding to researchers in South Africa is associated with a material difference in their productivity. They compare performance measures of researchers who were granted substantial funding against researchers with similar scholarly standing who did not receive such funding. They find that substantial funding is associated with raised researcher performance—although the increase is moderate, is strongly conditional on the quality of the researcher who receives the funding, and is greater in some disciplines than others. Moreover the cost per additional unit of output is such as to raise questions about the usefulness of the funding model. The implication is that public research funding will be more effective in raising research output where selectivity of recipients of funding is strongly conditional on the established track record of researchers.

In the case of Latin America, only a few contributions—mostly concentrated in Argentina and Chile—are available. For instance, studying the effect of the Chilean National Science and Technology Research Fund (Fondo Nacional de Desarrollo Científico y Tecnológico, FONDECYT), Benavente et al. (2007, 2012) find significant and positive impact in terms of publications, but no impact in terms of quality of scientific production. Chudnovsky et al. (2008), Ubfal and Maffioli (2011), and Ghezan and Pereira (2014) concentrate their efforts in unveiling the impacts of Argentinean (Fondo para la Investigación Científica y Tecnológica, FONCYT) on scientific productivity. Specifically, Chudnovsky et al. (2008) found a positive and statistically significant effect of subsidy on academic performance, especially for young researchers while Ubfal and Maffioli (2011) found a positive and significant impact of funding on collaboration measured by the number of co-authors for publications in peer-reviewed journals. In the case of Brazilian BIOTA (Brazilian Program on Biodiversity and Ecosystem Services) programme, Colugnati et al. (2014) finds a 10–20% increase in the scientific production of the beneficiaries of BIOTA in comparison with the control group (depending on the indicator considered). The same effect was observed with regard to co-authors. The effect was weaker when all output cited in researchers' CVs was considered, falling to about 30–40% and displaying less statistical significance. The contribution that is closer to ours is that of Bernheim et al. (2012) who studied the impact of the national system of researchers (Sistema Nacional de Investigadores, SNI) in Uruguay.[2] SNI provides ex post funding of researchers based on their (recent) past research performance through an assessment of their complete CV by means of an electronic platform. Their results show that being a researcher in SNI produces positive impacts in productivity indicators, with stronger effects on the lower (i.e. younger) category, where positive effects are also found with respect to technical production.

3. Research and development in Paraguay and the PRONII programme

Paraguay is a small, landlocked country in South America. With a population of almost 7 million people, the country traditionally exhibited one of the lowest levels of income in the region. In the recent decade, the Paraguayan economy grew rapidly, pushed by a commodity boom and the importance of electricity exports, which—in turn—enabled a cut of poverty levels down to 22% in 2014 (from 49% a decade earlier). This bonanza came together with a series of institutional innovations and reforms. The scientific and research and development (R&D) sector was no exception.

The investment in R&D in Paraguay more than tripled between 2005 and 2014, from US$6.5 million to US$31.9 million. Its share of Gross Domestic Product (GDP) grew slightly from 0.08% to 0.10%; however, it still lags behind compared to the regional average of 0.75% (RICYT 2016). Similarly to other Latin American countries (LAC), almost all of this R&D investment (85%) is publicly funded. Together with this increase in investments, the number of researchers doubled in the period from 760 in 2005 to 1,516 in 2014 (RICYT 2016), doubling the country's share in the number of active researchers in the Latin America and the Caribbean region (0.40%) but still below the country's share of population in the region. At the same time, the increase in the number of researchers has been accompanied by an improvement in their qualifications. In 2014, only 45% of researchers did not have postgraduate studies, a drop from 61% a decade earlier.

In turn, these increases in R&D investment and in the number of researchers induced an increase in the production of knowledge. The publications indexed in Science Citation Index and Scopus grew from 44 and 49, respectively, in 2005 to 133 and 152 in 2014. However, Paraguay only contributes with 0.13% of LAC scientific production. Most Scopus publications correspond to the areas of medical sciences (46.6%), agricultural science (18.4%), and natural sciences (19.3%).

In terms of productivity, although Paraguay managed to triple its scientific output, the growing investments in R&D induced a lower scientific productivity. In 2014, each million dollars of investment in R&D produced 4.8 papers in Scopus in comparison to the 7.5 papers per million published a decade earlier. This figure is still high in relation to the regional average of 2.8 publications per million,[3] but in line with the productivity of other small countries in the region.[4]

These improvements in R&D investment, number of researchers, and knowledge production happened in a context of a strengthening of the National Council for Science and Technology (CONACYT for its Spanish acronym), the agency responsible for the design, and implementation of STI policies in Paraguay.

In 2011, CONACYT created the National Research Incentive Programme (PRONII) with the objective of strengthening and expanding the scientific community of Paraguay. PRONII seeks to promote the research career in Paraguay, by categorizing researchers according to their scientific and technological production and providing economic incentives (subsidies) according to this categorization. It is worth mentioning that the National Research System (SNI) of both Uruguay and Mexico has inspired the PRONII.

The assessment and selection of researchers is by means of a standardized CV, entered in an electronic platform called CVPY[5] that is publicly available from the website of CONACYT. Applicants to PRONII are evaluated taking into account the following criteria:

1. Production of basic research, applied research, and technological outputs of proven quality.
2. Level of education.
3. Participation in the development of other researchers' capabilities (mainly through the direction of undergraduate and graduate theses).
4. Participation in the creation and strengthening of institutional capacities for research and experimental development.

The quality of research is judged taking into account:

1. Papers published in refereed journals. Indexed international journals are considered of greater value, followed by regional and then national journals.
2. Patents and original technological products.

3. Leadership in the field: international, regional, and/or national recognition, in that order of importance.

Given the small size of Paraguayan scientific community, the selection process involves an evaluation process of three tiers. First, each application is assessed by a Technical Commission (per field of science) that is formed of up to five members experts in the same field, and renewed with each application round. These reviewers could be either Paraguayan researchers (either in the country or abroad) or foreign reviewers. This commission issues a non-binding recommendation to the Scientific Committee (second tier), formed by up to five members of the same field of science who have a tenure of 2 years in the position. Each Scientific committee produces its own recommendations. Finally, the Honorary Scientific Committee decides whether or not to admit and categorizes each application individually.

Researchers accepted into the programme are categorized in one of four possible levels: Candidate, Level I, Level II, and Level III. In the 2011 edition of the programme only the researchers accepted as Level I, Level II, or Level III received monthly subsidies equivalent (approximately) to US$700 for Level I, US$1,400 for Level II, and US$2,100 for Level III. These monthly stipends are equivalent to 59%, 73%, and 77% of the yearly income as university professors, respectively.[6] These figures are rather generous in comparison to other similar incentives in the region.[7] This subsidy lasts for 2 years in the case of Level I, 3 years for Level II, and 5 years for Level III; after this period researchers are evaluated again. The researchers admitted as Candidate did not receive subsidies in the first call of the programme.

There are four scientific fields in PRONII: (1) Agricultural and Natural Sciences and Botany, (2) Health Sciences, Chemistry, and Animal Biology, (3) Social Sciences and Humanities, and (4) Engineering and Technology, Mathematics, Computer Science, and Physics.

In the 2011 call, 238 researchers were categorized and 29 were rejected.[8] The number of active researchers by field and level after the 2011 call are shown in Table 1. Nowadays, PRONII supports 386 researchers.

Table 1. Number of researchers that entered the programme in 2011 by field and category

Category\field	1	2	3	4	Total
Candidate	18	62	18	12	110
Level I	25	31	18	15	89
Level II	4	13	5	4	26
Level III	3	5	2	3	13
Total	50	111	43	34	238

Note: Fields of Science: (1) Agricultural and Natural Sciences and Botany, (2). Health Sciences, Chemistry and Animal Biology, (3) Social Sciences and Humanities, and (4) Engineering and Technology, Mathematics, Computer Science and Physics.

4. Data and some descriptive statistics

The data used in this article come from the CVs of all the applicants to PRONII that are available in the electronic platform CVPY of CONACYT.

The main focus of this research is on the following four dimensions of researchers' performance: bibliographical production, technical production, level of education, and training of new researchers. In Tables 2–5 we present information related to these dimensions for the following two periods: the period corresponding to the 2 years before the programme (2010–1), and the first 2 years after the call (2012–3).

The bibliographic production includes working papers, conference papers, published and/or accepted papers for publication, and books and books' chapters. Under the heading 'technical production' three types of works are grouped: (1) technical work (such as advisory activities, consulting, development of regulations and ordinances)[9]; (2) technological products (such as the production of new varieties of plants, prototypes, software); and (3) processes or techniques (such as development of management processes and analytical, instrumental, educational or therapeutic techniques).

In Tables 2–5 we can see that the bibliographic production, the technical production, the publication of articles, the number of theses under direction, and the level of education have increased in the period 2012–3 with respect to the period 2010–1 for almost all categories of researchers. The only exceptions were the Candidate researchers that have reduced the number of bibliographic products and the Level III researchers that published a smaller number of papers in 2012–3 in comparison with 2010–1.[10] It should be noted that although Candidates have reduced the average number of bibliographic production (understood in a broad sense), they have increased in the same period the number of publications in scientific journals, suggesting a change in strategy, where the emphasis is placed on better quality rather than on quantity alone.

5. Empirical strategy

The objective of this article is to estimate the impact of PRONII on researchers' productivity. To this end we exploit the fact that

Table 2. Mean of bibliographic production and articles in scientific journals by researcher category

Researcher category	Bibliographic production (mean per year) 2010–1	Bibliographic production (mean per year) 2012–3	Rate of increase (%)	Articles in scientific journals (mean per year) 2010–1	Articles in scientific journals (mean per year) 2012–3	Rate of increase (%)
Candidate	2.41	2.19	−9	0.78	0.88	12
Level I	4.61	5.57	21	1.63	1.70	4
Level II	5.46	7.44	36	2.19	2.92	33
Level III	6.17	7.79	26	2.13	2.00	−6

Source: Own elaboration based on CVPY.

researchers have increasing subsidies (according to their level obtained) and we compare the productivity of researchers in each level with the productivity of researchers from the previous level. Therefore, the different estimated impacts should be understood as marginal impacts due to the increase in the subsidies from one category to the next one. Candidate researchers are compared with applicants that were rejected.

The idea is that researchers in two adjacent levels are relatively similar but receive different subsidies (Candidate is the only category that does not receive subsidies). Therefore, we expect those receiving a higher subsidy to have a greater increase in productivity after the programme than the others in the previous level. Of course, even though researchers in two adjacent levels are potentially more similar than in non-adjacent groups, they are still potentially very different. To begin with, this is why they have been classified in different categories. Therefore, to ensure that we compare individuals that are relatively similar and that the only difference among them is that they receive different subsidies, we will use matching techniques.

We use two alternative methods to evaluate the impact of PRONII on researchers' productivity. The first is propensity score matching (PSM; Rosenbaum and Rubin 1983; Abadie and Imbens 2006) combined with difference-in-differences, and the second one is difference-in-differences with entropy balancing (Hainmueller 2012; Hainmueller and Xu 2013).

Table 3. Technical production by researcher category

Researcher category	Mean per year 2010–1	Mean per year 2012–3	Rate of increase (%)
Candidate	0.33	0.45	36
Level I	0.44	0.80	82
Level II	0.60	0.65	10
Level III	1.67	3.13	87

Source: Own elaboration based on CVPY.

Table 4. Number of theses under direction by research category

Research category	Undergraduate theses (mean per year)		Graduate theses (mean per year)	
	2010–1	2012–3	2010–1	2012–3
Candidate	0.07	0.21	0.05	0.10
Level I	0.11	0.58	0.09	0.61
Level II	0.02	0.12	0.21	0.60
Level III	0.00	0.21	0.58	0.46

Source: Own elaboration based on CVPY.

Since we cannot observe what would happen if the 'treated' researchers did not get the financial support provided by PRONII (the counterfactual), we need to find a proxy for the counterfactual, to compare them with the treated individuals. Taking the case of Candidates, researchers that did not get public financial support could be considered for a comparison (or control) group; however, it is possible that these researchers did not get support because of some particular characteristic that could also affect the outcome variables. For example, the level of education (e.g. if the individuals have a master's or a doctorate degree) is key to enter the PRONII at Candidate level, and at the same time the level of education could be an important predictor of the number of publications. Therefore, if we compare the publication performance of Candidates with that of the individuals that were rejected we are likely to observe that candidates publish more than the control group simply because they have a higher level of education and not necessarily because of the public subsidy.

Propensity score matching methods, under some assumptions, can be used to circumvent this problem.[11] The following briefly explains the rationale behind this strategy.

One of the key parameters of interest in this article is:

$$\tau_{ATT} = E[Y(1)|D = 1] - E[Y(0)|D = 1]$$

where τ_{ATT} is the average effect of PRONII on researchers that receive the subsidy; $E[Y(1)|D = 1]$ is the mean value of the outcome variable $Y(1)$ (e.g. number of publications) given that the researchers received the public subsidy provided by PRONII; and $E[Y(0)|D = 1]$ is the counterfactual (i.e. the expected value of outcome variable, $Y(0)$) for researchers in the treatment group in case they did not obtain (or obtain a lower level) of subsidy. $D = 1$ means that the researcher belongs to the treatment group.

Unfortunately, we do not observe the counterfactual. What we do observe is $E[Y(0)|D = 0]$, which in our case could be number of publications of those researchers that do not belong to PRONII ($D = 0$) and do not receive treatment (or subsidy). Of course, $E[Y(0)|D = 0]$ does not need to be equal to $E[Y(0)|D = 1]$ and therefore can introduce a bias to the estimation in case it is used as a proxy for $E[Y(0)|D = 1]$. Note that,

$$\tau_{ATT} = E[Y(1)|D = 1] - E[Y(0)|D = 1] - E[Y(0)|D = 0] + E[Y(0)|D = 0],$$

and therefore

$$E[Y(1)|D = 1] - E[Y(0)|D = 0] = \tau_{ATT} + bias,$$

where $bias \equiv E[Y(0)|D = 1] - E[Y(0)|D = 0]$. As previously noted,

Table 5. Highest educational level attained by researcher category (number of individuals)

Researchers category	2011				2013			
	Undergrad	Master	PhD	Total	Undergrad	Master	PhD	Total
Candidate	38	46	20	104	27	53	24	104
Level I	32	29	27	88	27	31	30	88
Level II	3	3	20	26	1	3	22	26
Level III	0	1	11	12	0	1	11	12
Total	73	79	78	230	55	88	87	230

Source: Own elaboration based on CVPY.

if researchers with particular characteristics tend to be selected in the treatment group and these characteristics affect outcomes, then there will be bias. On the contrary, if the assignment to both groups is completely random, such bias should not be a concern. Because this condition clearly does not hold in the case of PRONII, we have to do something else.

Assuming the differences between the treated and control groups come from observable characteristics (e.g. education before the programme, age, previous record of publication) that are not affected by the treatment, we can proceed to find researchers that are similar on these characteristics in both groups and compare them. The identification assumption is that, given a set of observable covariates X that are not affected by treatment, potential outcomes are independent of treatment assignment (this is called the conditional independence assumption). This implies that selection into the treatment group is only based on observable variables X that can be controlled for.

Usually, X is of high dimension. To deal with this dimensionality problem, propensity scores can be balanced. We can use the Xs to estimate the probability of being selected for treatment $P(D=1|X)=P(X)$—using a probit or logit model in the case of binary treatment—and use this probability to find similar researchers in both groups (treated and control).

The PSM estimator for average treatment effect on the treated is

$$\tau_{ATT}^{PSM} = E[Y(1)|D=1, P(X)] - E[Y(0)|D=0, P(X)].$$

Assuming conditional (on the propensity score, P(X)) independence of outcome variables with respect to treatment, this estimator is unbiased.

An additional important condition to use PSM is to have enough treated and control researchers on the common support. More formally, we need $0 < P(D=1X) < 1$. This condition ensures that researchers with the same values of X have a positive probability of being both participants and non-participants, and we avoid predicting perfectly if a researcher belongs to the control or the treatment group.

The matching algorithm used in this article is Nearest Neighbour Matching with replacement. In particular, for each treated researcher, we found the five nearest neighbours (matching partners) and compared them with the treated researcher. We will also report the results with the nearest neighbour as a robustness check.

Note that we are assuming that there are no non-observable variables that could affect the participation in the programme and simultaneously affect the performance of researchers. If this is not the case, and there are variables that could potentially affect the participation in the programme and the outcome that we cannot control that are fixed in time, for example, the type of institution where the researchers work (e.g. public vs. private, research vs. consultancy), we can use (in case we have at least two periods of time in our database) difference-in-differences together with matching to circumvent this problem. In this case the estimator of the average impact on the treated will be:

$$\tau_{ATT}^{DD-PSM} = E[Y_2(1) - Y_1(1)|D=1, P(X)] - E[Y_2(0) - Y_1(0)|D=0, P(X)].$$

The diff-in-diff PSM estimator τ_{ATT}^{DD-PSM} is the difference of the interest variable (e.g. number of publications) before (Period 1) and after (Period 2) the PRONII, among the treated and the control group compared on the common support (using PSM). This is a more robust estimator of the effect (in the sense that it allows for some non-observable heterogeneities) and therefore this is the one that we will be reporting in the results section.

As an alternative methodology we will use the entropy balance proposed by Hainmueller (2012) and Hainmueller and Xu (2013). The basic idea of this method is that it is possible to eliminate (under some conditions) the bias that comes from the differences between treated and control groups by assigning a weight to each control group individual to make them more similar to beneficiaries. The weighting is chosen in the following way (Hainmueller 2012):

$$\min_{w_i} H \equiv \sum_{i|D=0} w_i \log(w_i/q_i),$$

subject to balance and normalization constraints:

$$\sum_{i|D=0} w_i X_{ij} = m_j, \ \forall j$$

$$\sum_{i|D=0} w_i = 1 \quad \text{and } w_i \geq 0,$$

where w_i is the weight chosen or estimated for each control unit i, q_i is the base weight (usually chosen as 1/n, n being the number of control units). The balance constraints impose that the weighted mean of variable X_j in the control group (i.e. $\Sigma_{i|D=0} w_i X_{ij}$) must be equal to the mean of variable X_j in the treated group (i.e. m_j). The other constraints are normalization constraints.

Note that the procedure tries to minimize the difference between a uniform weight and the estimated weight subject to the weighted mean of variables in the control group being equal to the mean in the treated group.

Once these weights are estimated we run the regression of the outcome on the treatment indicator in the reweighted data.

6. Results

6.1 Probability of participation

In Tables 6–8 we show the probability of participating in the programme at the different levels with respect to the excluded category, which is the previous level, except in the case of Candidates (in which case the excluded category is the individuals that were rejected in the 2013 call of the programme[12]).

We started with a very broad specification of the probit models including the following variables for the pre-treatment period: Age, Sex, Master, PhD, Theses directed (concluded), Theses directed (in process), Technical production, Bibliographic production, Papers in Scientific Journals, Papers Scopus, Quality of papers (Mean SJR),[13] and dummies for the different scientific areas (Medical sciences, Social sciences, Humanities, Engineering and Technological sciences, Agriculture sciences, and Natural Sciences).[14] To avoid over-specification of the model we kept only the variables that were significant at the 10% confidence level in each of the different categories.

In Table 6 we present the probability of participation for Candidate researchers. The variables Master, PhD, Bibliographic production, and papers in scientific journals are positively correlated with being a Candidate researcher in 2011 (instead of being in the 'category' rejected by the programme and have applied in 2013). Engineering and Technology, Social Sciences, and Humanities areas are negatively correlated.[15] If we take into account that the programme at this entry level establishes the following conditions: Candidate researchers must demonstrate an important participation in research activities supported through publications and other

Table 6. Probit for candidate researchers

Variables	dF/dx	SE	*z*	P > *z*
Master's obtained prior to 2011	0.205	0.088	2.25	0.025
PhD obtained prior to 2011	0.273	0.095	2.47	0.014
Bibliographic production (mean 2010–1)	0.035	0.019	1.78	0.075
Papers in scientific journals (mean 2010–1)	0.627	0.111	5.31	0.000
Engineering and technology	−0.367	0.107	−3.00	0.003
Social sciences	−0.395	0.087	−4.15	0.000
Humanities	−0.413	0.145	−2.18	0.030
N = 220/pseudo $R^2 = 0.3549$				

Note: 0 category is rejected applicants in 2013.

Table 7. Probit for Level I researchers

Variables	dF/dx	SE	*z*	P > *z*
Age in 2011	0.026	0.005	4.98	0.000
Master's obtained prior to 2011	−0.166	0.093	−1.76	0.079
Theses directed (concluded) (mean 2010–1)	0.070	0.027	2.62	0.009
Bibliographic production (mean 2010–1)	0.061	0.020	3.05	0.002
Papers Scopus (mean 2010–1)	0.418	0.125	3.34	0.001
Medical sciences	−0.474	0.093	−4.26	0.000
Social sciences	−0.218	0.107	−1.91	0.056
N = 191/Pseudo $R^2 = 0.3506$				

Note: 0 category is Candidates in 2011.

means of communication or documentation of results, and should preferably be performing advanced-level training in master's or doctoral programmes; it seems that the screening process has been done properly, except for the bias against some areas.

The conditions established in the PRONII for researchers Level I are: to have a master's or doctoral degree or equivalent scientific production, having demonstrated over the course of the 5 years prior to the PRONII the ability to carry out original research independently. The probit presented in Table 7 shows that the variables that seem relevant to distinguish Level I from Candidate researchers are the bibliographic production, the publication record in indexed journals (a measure of quality of research), the theses that they direct, not having a master's degree, and the age. Belonging to the medical and social areas, other things equal, conspires against belonging to Level I. The variables bibliographic production, papers indexed in Scopus, theses directed (concluded) seem to be relevant to establish the ability to carry out original research independently as PRONII requires at this level. To have a master's degree seemed to be used as a way of discriminating Candidates from Level I researchers. The negative sign means that having a master's degree reduces the probability of belonging to Level I and increases the probability of belonging to Candidate level, probably because evaluators interpreted this as evidence that the researcher did not end her/his education process or do not have the right education level for Level I researchers (even when this is not a condition established by the programme). An interesting finding is that age was also used to differentiate Level I researchers from Candidates. This is clearly another not intended result of the evaluation process.

To be accepted as a Level II researcher, the requisites established by PRONII include to hold a PhD or an equivalent scientific output,

Table 8. Probit for Level II researchers

Variables	dF/dx	SE	*z*	P > *z*
Master's obtained prior to 2011	0.424	0.219	2.01	0.045
PhD obtained prior to 2011	0.651	0.129	3.97	0.000
Mean SJR (2010–1)	0.248	0.090	2.71	0.007
Medical sciences	0.406	0.167	2.57	0.010
Social sciences	0.278	0.162	1.95	0.051
N = 102/pseudo $R^2 = 0.331$				

Note: 0 category are researchers Level I that were part of PRONII from 2012 to 2014.

strong track record of work, particularly in the 5 years prior to each call of PRONII, and having developed one's own line of research with sustained production of original knowledge. Activities aimed at capacity building for research will also be assessed.

The probit shows that indeed having a PhD and publications of higher quality (proxied by the mean SCImago journal ranking of the journals where they publish) increases the likelihood of belonging to Level II instead of Level I. To have a master's degree is also used as an element to distinguish, other things equal, Level II from Level I researchers. However the number of theses directed that is a proxy for capacity building for research does not appear in the probit as an element that discriminates Level II from Level I. Having medical and social sciences as the main research area increases the probability of belonging to Level II relative to Level I.

6.2 Impacts

This section presents the results of the impact evaluation. In Table 9 are presented the results for each of the variables analysed and for each of the three alternative methods (one neighbour PSM with diff-in-diff, five neighbours PSM with diff-in-diff, ebalance with diff-in-diff). The propensity scores were estimated with the probit models presented in the previous section. In the Appendix we show mean tests for the variables used in this evaluation to show evidence of a good matching on observable characteristics of researchers in the control and treated group. In the Appendix, we also report the result of the entropy balancing in terms of the mean equalization for some relevant variables.

The results show that the short-run effects for the entry level of the programme (i.e. Candidate researchers) seem to be concentrated in the bibliographic production of higher quality, that is, in the publication of papers in scientific journals and papers indexed in Scopus. In any case, and taking into account the length of time taken to get a paper from a working paper stage to a published paper in a scientific journal, the increase on average of 0.25 papers per year published in the 2 years after the start of the programme is not negligible. In the case of Scopus papers the increase is of 0.07 papers per year. It is important to notice that these results are not very robust due to the method used in the estimations; therefore they should be handled with care.

When the performance of level I researchers is compared to Candidate researchers, we find that the increase in the subsidy from one category to the other generates a positive impact on the directed theses in process of around one additional thesis per year in average, the production of one additional bibliographic output per year, the production of 0.5 technical output per year, and one additional PhD for every 30 researchers. In turn, the quality of their publications seems to be reduced, at least as judged by the average SCImago Journal Ranking of the journals where they were published. The

Table 9. Impact of PRONII on researchers' performance

	Method	Candidate		Level I		Level II—2 years		Level II—3 years	
		Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Master's	1 neighbour	0.06395	0.10400	−0.08772	0.06865	−0.10317	0.06723	−0.10317	0.06723
	5 neighbours	0.04198	0.08033	0.00702	0.06379	−0.04938	0.04819	−0.04938	0.04819
	ebalance	−0.03335	0.04840	0.01108	0.03056	−0.03265	0.03336	−0.03265	0.03336
PhD	1 neighbour	−0.03333	0.06013	0.03509	0.04920	0.10317	0.08952	0.10317	0.08952
	5 neighbours	−0.01341	0.03971	−0.02105	0.04028	0.10494	0.08335	0.10494	0.08335
	ebalance	0.02869	0.01856	0.03385*	0.01940	0.07078	0.05285	0.07078	0.05285
Theses directed (concluded)	1 neighbour	0.20666	0.50373	0.71930	0.51048	−2.48264**	1.08854	−1.60632*	0.89054
	5 neighbours	0.24020	0.37957	0.46667	0.48134	−2.21458**	0.88663	−1.56096**	0.72711
	ebalance	0.31527	0.26102	0.68606	0.49199	−0.42614	1.30708	−0.12742	0.92588
Theses directed (in process)	1 neighbour	0.09932	0.29938	1.32456***	0.40131	−1.84276**	0.85399	−0.63608	0.61387
	5 neighbours	0.02558	0.21330	1.02632***	0.37410	−1.86613***	0.63496	−0.63727	0.47940
	ebalance	−0.10100	0.12717	0.78868**	0.37530	−0.92176	1.04170	0.23856	0.75072
Technical production	1 neighbour	−0.02693	0.22951	0.66667	0.43558	−0.02728	0.36889	0.02083	0.36354
	5 neighbours	−0.12484	0.20898	0.29825	0.30485	0.08681	0.31476	0.13997	0.31648
	ebalance	0.06685	0.14818	0.45875***	0.16348	0.19167	0.27123	0.26419	0.29216
Bibliographic production	1 neighbour	0.11043	0.44525	0.98246*	0.55055	2.09077	1.41556	1.75331	1.35448
	5 neighbours	0.18376	0.37993	0.99649*	0.55092	1.63819	1.33368	1.72106	1.27455
	ebalance	−0.39826	0.33818	1.12534	1.06778	−1.77461	1.72218	−1.41112	1.57987
Papers in scientific journals	1 neighbour	0.24623	0.15155	0.21930	0.27183	0.52976	0.93772	0.08730	0.81234
	5 neighbours	0.25659**	0.12882	0.28070	0.24042	0.76443	0.88150	0.47693	0.77525
	ebalance	−0.13419	0.17559	0.34139	0.24612	−1.38005	1.74868	−1.07708	1.31793
Papers Scopus	1 neighbour	0.05561	0.05951	0.12281	0.10657	0.54514	0.43631	0.03687	0.33646
	5 neighbours	0.05143	0.04517	0.04386	0.09080	0.47454	0.44052	0.15180	0.32377
	ebalance	0.07823**	0.03959	−0.17305	0.13659	0.07819	0.35122	−0.72723	0.64523
Quality of papers (mean SJR)	1 neighbour	−0.00728	0.05581	−0.01079	0.10894	0.44091***	0.13412	0.35881***	0.11455
	5 neighbours	−0.00985	0.04409	−0.07242	0.08498	0.30238**	0.12582	0.29134***	0.10948
	ebalance	−0.01610	0.04208	−0.18413*	0.10105	0.17902	0.16554	0.16155	0.16861

Note: $^{*}P<0.1$, $^{**}P<0.05$, $^{***}P<0.01$.

level of robustness of these results across estimation methods is heterogeneous. The result that is more robust to the estimation method is the one related to the direction of theses.

In the case of Level II researchers the impact of the programme seems to be negative on the number of theses directed (both concluded and in process) and positive on the indicator of quality of their research. On average they direct two theses less per year than the previous level but they publish on journals that have on average of a higher score of between 0.3 and 0.44 points. Researchers Level II have to reapply to be kept in the programme every 3 years, therefore we have good information from their CVs to measure the impact of the programme after 3 years. As can be seen in Table 9, the results after 3 years in the programme are qualitatively similar to those found after 2 years.

Note that in the case of Level II researchers we are only measuring the additional performance with respect to Level I, therefore we should expect them to perform better than Candidates along the lines commented in the previous paragraph and in addition along the lines discussed in the case of Level I *vis a vis* Candidates.

We are not reporting here the results for Level III researchers since the sample is very small (we have in our sample only eight individuals in this level).

7. Cost-effectiveness analysis

In this section, we perform a cost-effectiveness analysis. The objective is to understand, given the impacts reported in the previous section, what are the costs involved in generating additional scientific and technical outputs.

Methodologically, we aim to produce an estimate of the total number of different outputs for the researchers participating in the programme, compared with a situation with no programme. Taking into account that it is not possible to find a good control group for the researchers admitted in Levels I and II (including those who were rejected by the programme), we followed a strategy of computing the effects of being in one category (say e.g. Level II) versus being in the previous one (Level I). This estimated effect is the *incremental effect* of the programme for Level II with respect to Level I, that is, the effect that is due to the increase in the monetary incentive from one level to the other. The *total effect* for Level II researchers can be computed as:

Total Effect Level II = Incremental effect Level II vs. Level I + Incremental Effect Level I vs. Candidate + Incremental effect Candidate vs. Excluded,

similarly,

Total Effect Level I = Incremental Effect Level I vs. Candidate + Incremental effect Candidate vs. Excluded

and

Total Effect Candidate = Incremental effect Candidate vs. Excluded.

To compute the total outputs of the programme, we have an additional difficulty. In the previous sections we have produced three estimates for each output and category. Of course, choosing one estimation over another implies different results. Therefore, we have computed the results under two scenarios, one that we call a positive scenario and a second called pessimistic scenario.

The assumptions of the optimistic scenario are the following: (1) if at least one of the coefficients in Table 9 (for a given output and researcher category) is significant, we use the largest (for a given output in that researcher category); in case none of them are significant we consider the impact to be zero; (2) as explained above, each coefficient in Table 10 is understood as incremental with respect to the previous level, therefore the impact in terms of the 'no programme' situation is the sum of coefficients across levels for each given output; and (3) in the case of the coefficient for additional PhDs, we are using half the value of the estimated coefficient, since the variable was defined as the number of additional PhDs after 2 years into the programme.

In the pessimistic scenario, if at least one of the coefficients for a given output and researcher category is non-significant we take the effect as zero. If all coefficients are significant we take the smallest of them.

Table 10. Cost-effectiveness analysis

	Additional output *per researcher per year*			Total additional output *per level per year*			Total
	Candidate	Level I	Level II	Candidate	Level I	Level II	
PhD	0.00	0.02	0.02	0.0	1.5	0.4	1.9
Theses directed (in process)	0.00	1.32	−0.52	0.0	117.9	−13.5	104.4
Theses directed (concluded)	0.00	0.00	−2.21	0.0	0.0	−57.6	−57.6
Technical output	0.00	0.46	0.46	0.0	40.8	11.9	52.8
Bibliographic output	0.00	1.00	1.00	0.0	88.7	25.9	114.6
Papers in scientific journals	0.26	0.26	0.26	28.2	22.8	6.7	57.7
Papers Scopus	0.08	0.08	0.08	8.6	7.0	2.0	17.6
Number of researchers per level				110	89	26	225
Subsidies (million US$, per year per level)					0.76	0.44	1.20

Note: Effect of the programme on different outputs (categories Candidate to Level II only). Positive scenario.

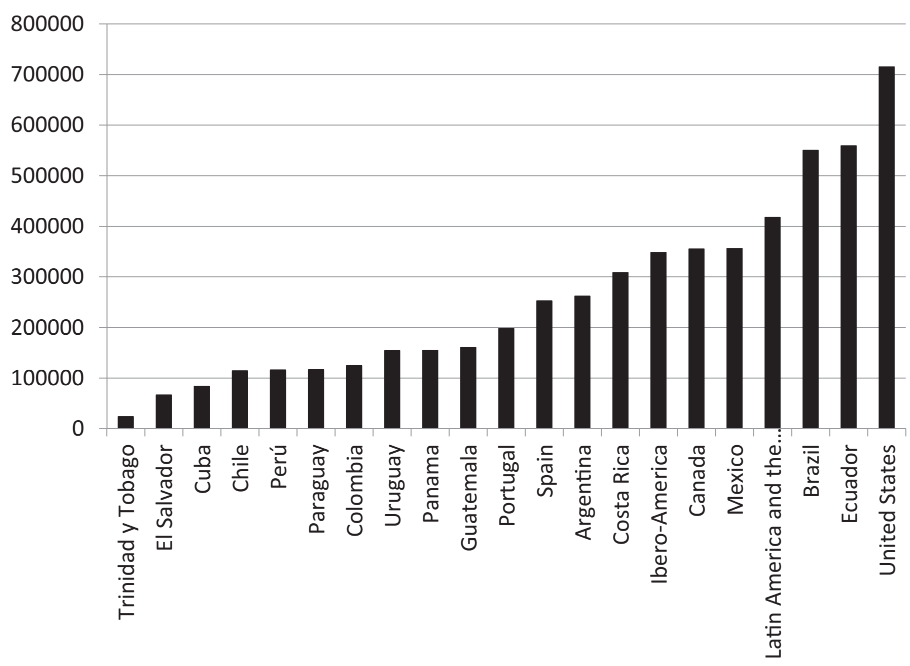

Figure 1. R&D spending per Scopus paper in different countries and regions (2011, in US$).

Source: Own elaboration based on RICYT (2016).

It should be noted that this analysis tends to slightly underestimate the costs of the programme since we are not computing its administrative costs. We only consider the subsidies that researchers have received. Finally, note that the programme has multiple outcomes. Therefore we will not be able to compute the cost of each of the outputs, since there is no easy way of aggregating them. In any case we can comment on a few things about costs of individual outputs.

Table 10 presents the results of the positive scenario. The total subsidies paid out annually sums US$1.2 million. This allocation generates the following additional outputs per year: 2 PhDs, 104 theses directed (in process), 53 technical output, 115 bibliographic output, 58 papers published in scientific journals, and 18 papers published in Scopus. The programme reduces to 58 the thesis directed (concluded).

According to statistics published by the CONACYT in Paraguay, the total R&D in Paraguay in the year 2011 was US$14.3 million. Therefore, the subsidies paid out during 2012 represented an additional 13.6% of resources. Prior to PRONII, the number of papers published in SCOPUS was 122 (CONACYT 2012). Hence, the programme implied an impact of 14.4% (17.6 of 122) in the production of Scopus papers in the country. If we compute the 'cost' of each Scopus paper before the programme as the ratio of R&D spending over the number of Scopus papers in the country, we arrive to the amount of US$116,898 per paper. Meanwhile the 'cost' of generating one additional Scopus paper in the programme was US$68,256; in other words, only 58% of the previous cost in the country. The average cost (in terms of R&D spending) of producing a Scopus paper in Latin America and the Caribbean is US$418,000 as can be seen in Fig. 1 (RICYT 2016).

Under the pessimistic scenario we only have a positive impact on the number of theses directed (in process). The impact is of 91 additional theses directed.

A final warning with respect to the previous results: they are short-run results, that is, only 2 years after the programme. Probably the most relevant effects of this kind of programmes can be only observed after 5 or more years. Therefore, a long-run evaluation of the programme is strongly advised before extracting stronger conclusions about its effectiveness or not.

8. Conclusions

The objective of this article is to perform an impact evaluation of a programme that provides ex post subsidies to researchers, as a complement to their wages. The analysis of the effects of this type of subsidies that are prevalent in Latin America has received little attention in the literature. Moreover we are able to analyse the impact of the programme in dimensions of researchers' productivity that have been mostly overlooked previously (probably because of lack of data), such as technical production, own education, and other researchers' training.

One important point to stress is that this is a short-run impact evaluation of the programme, since we are analysing the impacts after only 2 years since the beginning of the programme. Another important issue that we must keep in mind when analysing the results and their significance, is that we have a small number of observations, particularly for the case of Level II researchers. Both facts go in the direction of not finding significant effects.

We find results that suggest that the short-term effects for the entry level to the programme (Candidates) is mainly on the production of higher quality literature, that is, in the publication of articles in scientific journals and articles indexed in Scopus. However, the result is not very robust to the estimation method. When Level I researchers are compared to Candidates, we find that the programme generates a positive impact on the number of theses directed by researchers. The impact is of approximately one additional thesis per year and per researcher. This result is robust to alternative methods of estimation. We also find other less robust (to methods of estimations) impacts: one additional bibliographic product and 0.5 additional technical products per year and per researcher and one additional researcher with PhD every 30 researchers at the end of the second year of the programme. Instead, the quality of publications seems reduced. For the case of Level II researchers, when compared with the previous category, we find that the programme appears to have a negative impact on the number of thesis (both completed and in progress) and positive effect on the quality of publications. On average, Level II researchers directed two theses less per year compared to the previous level, while published in journals that have on average a higher score. However the statistical significance of these impacts is not robust to alternative methods of estimation.

We have performed a basic cost-effectiveness analysis under two different scenarios. Under the positive one, the programme had an important and relatively high effect. The pessimistic one implies a very limited impact. Still, it is important to underline that a more definitive evaluation of the programme will need to take into account the long-term effects that can only be observed after many more years.

Finally, one should make note on how well the evaluators have applied the entry criteria for the different level. In general we found that the probability of entry is affected by the variables that are supposed to be relevant to categorize researchers in those categories. However we found a couple of exceptions. The first one refers to the fields that researchers belong to. In some cases there is evidence that this area was relevant to explain the categorization in one level as opposed to another. The second one is age, which seemed to be a relevant variable, other things equal, to explain the categorization in Level I instead of Level II. These two variables were not supposed to matter for the classification according to the evaluation criteria.

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Notes

1. Prior to 2012, Paraguay did not produce regular and reliable standardized indicators of R&D and/or production. The limited institutional capabilities of CONACYT, the research-funding agency, explain the type of application procedure and type of instrument that was implemented. D'onofrio (2009) highlights the importance of electronic CVs as potential sources of information for funding agencies, allowing the production of output indicators.
2. Uruguayan and Mexican SNI programmes have served as an inspiration for the Paraguayan PRONII under analysis here. In the case of Mexico there is no formal impact evaluation of the programme. One of the only contributions on the programme is Gonzálezand Veloso (2007) who analyses what

factors affect productivity of a group of 14,328 researchers, in all fields of knowledge, who have been part of the Mexican National System of Researchers (SNI), for at least 1 year, from 1991 to 2002. The National System of Researchers was created in 1984 to enhance the quality and productivity of researchers in Mexico. It gives pecuniary compensation, as a complement of salary, to the most productive researchers. SNI grants represent on average 30% of the income of researchers in the programme.

3. This average is heavily affected by the productivity levels of Brazil (2.25 papers in Scopus per US$ million in R&D) and Argentina (3.6 publications per million of investment). With a yearly production of about 65,000 and 12,000 Scopus paper per year, respectively, Brazil and Argentina account for 65% of the publications of the region.
4. For example, while Uruguay produces 7 publications per million of investment, Costa Rica obtains 2.8 publications per million (5.8 million in 2004), and Ecuador publishes 2.1 per million (5.1 publications per million in 2005).
5. Several LAC have adopted in the past decade a standardized platform to register and maintain their researchers' information. The majority of these platforms contain similar information since they were developed based on Brazil's 'Plataforma Lattes' and its regional adaptation named CvLAC. Hence, the methods presented here have the potential to be used for data from other countries in the region.
6. These percentages are our own calculation based on salary information from the Universidad Nacional de Asunción (UNA), the largest public university in the country. For Level III, we considered the salaries for Docente Investigador Exclusivo (US$2,500), for Level II we used those for Docente Investigador (US$1,800), and for Level I we took those of Docente Técnico (US$1,100). We considered that university professors are paid 13 salaries in a year, and PRONII only provides 12 stipends. Individual salary data from UNA is available at: http://www.una.py/index.php/nomina.
7. In the case of the Uruguayan SNI, the incentive programme that PRONII emulates, the additional subsidy that the research agency provides accounts in general for no more than an additional 20% of the researcher's salary.
8. In 2012, a total of 597 researchers have uploaded their CV into CVPY.
9. This type of production represents the bulk of the technical production, and tends to exhibit the larger growth rates.
10. This decline might be due to life cycle effects as presumably this group includes the older researchers with declining bibliographic productivity.
11. See Caliendo and Kopeinig (2008) for a very intuitive presentation of these methods.
12. We have only 29 rejected individuals in the 2011 call, and this is a very small number, this is why we choose to use the rejected individuals in the 2013 call as a potential control group. It is important to notice that 14 of the individuals rejected in the call 2011 are also rejected in the call 2013 and therefore they are also in the control group.
13. The SCImago Journal & Country Rank is a portal that includes the journals and country scientific indicators developed from the information contained in the Scopus database (Elsevier B.V.). These indicators can be used to assess and analyse scientific domains. The SCImago Journal Rank (SJR) indicator, based on the Google algorithm, shows the visibility of the journals contained in the Scopus database from 1996.
14. Natural sciences is the excluded category.
15. As mentioned previously we are using as a control group for the Candidates the group of individuals that applied to be part of the programme in 2013 and were rejected. This group in fact includes almost 50% of the individuals that also applied in 2011. We are not using as a control group the 2011 applicants that were rejected because this is a very small control group. But in fact the results found using this alternative control group are similar to the results that we will be analysing in the following sections and are available upon request.

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Appendix

Table A1. Definition of indicators of researchers' performance used in the empirical exercises

Variable	Definition
1. Researchers' performance indicators	
Master's	Indicator variable, =1 if the researcher's maximum education level is a Master's degree
PhD	Indicator variable, =1 if the researcher's maximum education level is a PhD degree
Theses directed concluded	Number of concluded direction of undergraduate and graduate theses per year
Theses directed in process	Number of ongoing direction of undergraduate and graduate theses per year
Technical production	Number of yearly technical outputs (this includes technical work, technological products, and new processes or techniques)
Bibliographic production	Number of yearly written research publications (this includes papers in both scientific and non-scientific publications, works published in events, publication of books and book chapters, and working papers)
Papers in scientific journals	Number of yearly papers published or accepted for publication in scientific journals
Papers in Scopus	Number of yearly papers published in Scopus journals
Quality of Papers (mean SJR)	Mean SJR rank of the journals in which the researcher published that year
2. Area of science	
Agricultural sciences	Indicator variable, =1 if the researcher's specialization is in Agricultural Sciences
Natural sciences	Indicator variable, =1 if the researcher's specialization is in Natural Sciences
Engineering and Technology	Indicator variable, =1 if the researcher's specialization is in Engineering and Technology
Medical sciences	Indicator variable, =1 if the researcher's specialization is in Health Sciences
Social sciences	Indicator variable, =1 if the researcher's specialization is in Social Sciences
Humanities	Indicator variable, =1 if the researcher's specialization is in Humanities

Note: When estimating the Probit models for the estimation of propensity scores we use the pre-treatment values of the performance indicators. In those cases we are using educational level attained by 2011 in the case of *Master's* and *PhD*, and the mean values for 2010 and 2011 for the remaining variables. On the other hand, the variables used for DiD impact evaluation are defined as the change in variables before and after PRONII. As a result, we use the change in Master's and PhD attainment between 2013 and 2011, and the change in mean production in 2012 and 2013 versus mean production in 2010 and 2011 for the remaining variables.

Table A2. Candidate, mean test 1 neighbour

Variable		Mean		% bias	% reduct	*t*-test	
		Treated	Control		bias	*t*	P > t
Master's	Unmatched	0.422	0.405	3.4		0.25	0.804
	Matched	0.443	0.471	−5.8	−72	−0.34	0.737
PhD	Unmatched	0.183	0.144	10.6		0.79	0.433
	Matched	0.200	0.286	−23.1	−117.9	−1.18	0.240
Theses directed (concluded)	Unmatched	0.771	0.653	7.4		0.55	0.584
	Matched	0.879	0.724	9.7	−31.6	0.49	0.627
Theses directed (in process)	Unmatched	0.170	0.054	26.7		1.98	0.049
	Matched	0.143	0.152	−2	92.5	−0.09	0.931
Technical production	Unmatched	0.335	0.297	4.4		0.33	0.745
	Matched	0.371	0.138	27.3	−521.9	1.55	0.124
Bibliographic production	Unmatched	2.413	0.914	71.2		5.28	0.000
	Matched	1.500	0.707	−9.8	86.2	−0.56	0.578
Papers in scientific journals	Unmatched	0.784	0.095	122.6		9.13	0.000
	Matched	0.314	0.271	7.6	93.8	0.66	0.511
Papers Scopus	Unmatched	0.101	0.041	26.9		2.00	0.047
	Matched	0.093	0.036	25.4	5.4	1.55	0.123
Quality of papers (mean SJR)	Unmatched	0.078	0.022	31.1		2.32	0.021
	Matched	0.060	0.019	23	26	1.45	0.149

Table A3. Candidate, mean test 5 neighbours

Variable		Mean		% bias	% reduct	*t*-test	
		Treated	Control		bias	*t*	P > t
Master's	Unmatched	0.422	0.405	3.4		0.25	0.804
	Matched	0.443	0.481	−7.6	−126.9	−0.44	0.657
PhD	Unmatched	0.183	0.144	10.6		0.79	0.433
	Matched	0.200	0.177	6.2	41.6	0.35	0.730
Theses directed (concluded)	Unmatched	0.771	0.653	7.4		0.55	0.584
	Matched	0.879	0.768	6.9	6.2	0.38	0.707
Theses directed (in process)	Unmatched	0.170	0.054	26.7		1.98	0.049
	Matched	0.143	0.060	19	28.8	1.38	0.169
Technical production	Unmatched	0.335	0.297	4.4		0.33	0.745
	Matched	0.371	0.178	22.6	−414.1	1.26	0.208
Bibliographic production	Unmatched	2.413	0.914	71.2		5.28	0.000
	Matched	1.500	1.876	−17.9	74.9	−0.79	0.433
Papers in scientific journals	Unmatched	0.784	0.095	122.6		9.13	0.000
	Matched	0.314	0.294	3.5	97.1	0.31	0.759
Papers Scopus	Unmatched	0.101	0.041	26.9		2.00	0.047
	Matched	0.093	0.028	28.8	−7.2	1.77	0.079
Quality of papers (mean SJR)	Unmatched	0.078	0.022	31.1		2.32	0.021
	Matched	0.060	0.016	24.7	20.6	1.57	0.118

Table A4. Candidate, mean before and after ebalance

Variables	Before		After	
	Treat mean	Control mean	Treat mean	Control mean
Master	0.422	0.4054	0.422	0.4221
PhD	0.1835	0.1441	0.1835	0.1836
Bibliographic production	2.413	0.9144	2.413	2.411
Engineering and Tech. sciences	0.06422	0.1982	0.06422	0.0644
Social sciences	0.1927	0.3964	0.1927	0.1933
Humanities	0.02752	0.07207	0.02752	0.02755

Table A5. Level 1 mean tests 1 neighbour

Variable		Mean		% bias	% reduct	t-test	
		Treated	Control		bias	t	P > t
Master's	Unmatched	0.318	0.417	−20.6		−1.42	0.159
	Matched	0.386	0.404	−3.6	82.3	−0.19	0.850
PhD	Unmatched	0.307	0.194	26.1		1.81	0.072
	Matched	0.228	0.333	−24.4	6.6	−1.25	0.215
Theses directed (concluded)	Unmatched	2.244	0.709	55.9		3.97	0.000
	Matched	1.175	1.026	5.4	90.3	0.45	0.651
Theses directed (in process)	Unmatched	0.261	0.175	18.8		1.30	0.195
	Matched	0.184	0.430	−53.3	−183.6	−2.19	0.030
Technical production	Unmatched	0.438	0.330	11.4		0.78	0.435
	Matched	0.289	0.640	−37.4	−226.7	−1.40	0.163
Bibliographic production	Unmatched	4.636	2.510	58.5		4.15	0.000
	Matched	3.079	2.439	17.6	69.9	1.60	0.111
Papers in scientific journals	Unmatched	1.653	0.825	44.3		3.16	0.002
	Matched	0.921	0.658	14.1	68.2	1.49	0.138
Papers Scopus	Unmatched	0.443	0.107	51.9		3.70	0.000
	Matched	0.184	0.281	−14.9	71.3	−1.18	0.240
Quality of papers (mean SJR)	Unmatched	0.219	0.083	41.2		2.90	0.004
	Matched	0.193	0.212	−5.7	86.3	−0.24	0.808

Table A6. Level I mean tests 5 neighbours

Variable		Mean		% bias	% reduct	t-test	
		Treated	Control		bias	t	P > t
Master's	Unmatched	0.318	0.417	−20.6		−1.42	0.159
	Matched	0.386	0.453	−13.8	32.9	−0.72	0.475
PhD	Unmatched	0.307	0.194	26.1		1.81	0.072
	Matched	0.228	0.267	−8.9	65.7	−0.47	0.637
Theses directed (concluded)	Unmatched	2.244	0.709	55.9		3.97	0.000
	Matched	1.175	1.314	−5	91	−0.37	0.715
Theses directed (in process)	Unmatched	0.261	0.175	18.8		1.30	0.195
	Matched	0.184	0.284	−21.7	−15.5	−1.03	0.307
Technical production	Unmatched	0.438	0.330	11.4		0.78	0.435
	Matched	0.289	0.400	−11.8	−2.9	−0.57	0.571
Bibliographic production	Unmatched	4.636	2.510	58.5		4.15	0.000
	Matched	3.079	2.549	14.6	75.1	1.30	0.196
Papers in scientific journals	Unmatched	1.653	0.825	44.3		3.16	0.002
	Matched	0.921	0.881	2.2	95.1	0.22	0.826
Papers Scopus	Unmatched	0.443	0.107	51.9		3.70	0.000
	Matched	0.184	0.189	−0.8	98.4	−0.07	0.941
Quality of papers (mean SJR)	Unmatched	0.219	0.083	41.2		2.90	0.004
	Matched	0.193	0.137	16.9	59	0.81	0.420

Table A7. Level I, mean before and after ebalance

Variables	Before		After	
	Treat mean	Control mean	Treat mean	Control mean
Age	46.51	39.61	46.51	46.51
Master's	0.3182	0.4175	0.3182	0.3181
Theses directed (concluded)	2.244	0.7087	2.244	2.242
Bibliographic production	4.636	2.51	4.636	4.636
Medical sciences	0.2614	0.4175	0.2614	0.2616
Social sciences	0.1818	0.1942	0.1818	0.1817

Table A8. Level II mean tests 1 neighbour

Variable		Mean		% Bias	% Reduct	*t*-test	
		Treated	Control		bias	*t*	P > *t*
Master's	Unmatched	0.115	0.329	−52.6		−2.13	0.035
	Matched	0.167	0.333	−41	22	−1.14	0.261
PhD	Unmatched	0.769	0.289	108.2		4.69	0.000
	Matched	0.667	0.500	37.6	65.3	1.00	0.324
Theses directed (concluded)	Unmatched	2.385	1.928	16.2		0.70	0.489
	Matched	2.694	1.496	42.5	−162.4	1.42	0.165
Theses directed (in process)	Unmatched	0.365	0.276	14.4		0.70	0.486
	Matched	0.417	0.139	45	−211.3	1.36	0.181
Technical production	Unmatched	0.596	0.414	21.4		0.95	0.342
	Matched	0.722	0.499	26.3	−22.9	0.65	0.520
Bibliographic production	Unmatched	5.462	4.349	23.6		1.14	0.256
	Matched	4.722	3.440	27.2	−15.3	1.03	0.311
Papers in scientific journals	Unmatched	2.192	1.625	20.9		0.95	0.342
	Matched	2.028	1.572	16.8	19.7	0.48	0.635
Papers Scopus	Unmatched	0.865	0.382	59.8		2.80	0.006
	Matched	0.889	0.510	46.8	21.8	1.12	0.270
Quality of papers (mean SJR)	Unmatched	0.482	0.207	59.1		2.79	0.006
	Matched	0.382	0.501	−25.7	56.4	−0.56	0.576

Table A9. Level II mean tests 5 neighbours

Variable		Mean		% Bias	% Reduct	*t*-test	
		Treated	Control		bias	*T*	P > *t*
Master	Unmatched	0.115	0.329	−52.6		−2.13	0.035
	Matched	0.167	0.430	−64.9	−23.3	−1.75	0.089
PhD	Unmatched	0.769	0.289	108.2		4.69	0.000
	Matched	0.667	0.463	46	57.5	1.22	0.229
Theses directed (concluded)	Unmatched	2.385	1.928	16.2		0.70	0.489
	Matched	2.694	1.435	44.6	−175.6	1.46	0.154
Theses directed (in process)	Unmatched	0.365	0.276	14.4		0.70	0.486
	Matched	0.417	0.224	31.2	−116.3	0.88	0.384
Technical production	Unmatched	0.596	0.414	21.4		0.95	0.342
	Matched	0.722	0.680	4.9	77	0.12	0.905
Bibliographic production	Unmatched	5.462	4.349	23.6		1.14	0.256
	Matched	4.722	3.694	21.8	7.6	0.74	0.465
Papers in scientific journals	Unmatched	2.192	1.625	20.9		0.95	0.342
	Matched	2.028	1.397	23.2	−11.3	0.77	0.449
Papers Scopus	Unmatched	0.865	0.382	59.8		2.80	0.006
	Matched	0.889	0.404	59.9	−0.2	1.66	0.107
Quality of papers (mean SJR)	Unmatched	0.482	0.207	59.1		2.79	0.006
	Matched	0.382	0.464	−17.8	69.9	−0.42	0.680

Table A10. Level II, mean before and after ebalance

Variables	Before		After	
	Treat mean	Control mean	Treat mean	Control mean
Master	0.1154	0.3289	0.1154	0.1156
PhD	0.7692	0.2895	0.7692	0.7687
Quality of papers (mean SJR)	0.4822	0.2074	0.4822	0.4815
Medical sciences	0.4231	0.2632	0.4231	0.4228
Social sciences	0.1923	0.1316	0.1923	0.1921