Money for Science? The Impact of Research Grants on Academic Output

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Motivation

- The failure of the market system to achieve an optimal resource allocation for scientific activity provides a rationale for public funding of science
- As public resources are spent in funding academic research, it is natural to question the results obtained with these resources
- We evaluate the impact of subsidies on the academic performance of researchers in Argentina

Related literature

- Previous literature has focused on developed countries
  - Arora, David, and Gambardella (1998) evaluate the effect of an Italian program funding academic biotechnology research and find a low average elasticity of research output with respect to funding
  - Arora and Gambardella (2006) assess the impact of NSF funding on basic economic research in the USA, finding a positive impact for young economists
  - Jacob and Lefgren (2007) show that NIH postdoctoral fellowships increase publications and citations by about twenty per cent in the five years following grant application
  - Goldfarb (2001) measures the impact of a NASA aerospace engineering program and finds a positive effect on the number of publications, though there is evidence that higher quantity was achieved at the expense of the quality of publications

Our contribution

- We focus on the impact of scientific research grants on academic performance in a developing country
  - Researchers in developing countries face more difficult constraints for undertaking scientific activity than those in developed countries
  - In developing countries the existence of private mechanisms of funding for science is lower than in developed countries
  - And the infrastructure conditions for scientific research are often poor due to budget restrictions

The context

- Argentina's level of expenditure in R&D activities is relatively low (0.5% of its GDP)
- Before the creation of FONCYT the main source of public funding for scientific research was the National Council of Technical and Scientific Research (CONICET), an institution based on the formula of a "career researcher" by which scientists are permanent staff of the Federal Government

The FONCYT program

- The FONCYT was created in 1997 and its objective is to grant funds in the form of non-reimbursable subsidies to scientific research projects
- These projects must be developed by researchers working at public or private, non-profit organizations located in Argentina
- The FONCYT subsidy allows researchers to fund inputs, purchase of bibliography, research assistants, trips to participate in scientific conferences, but the salaries of the researchers are not fundable

The selection process

- All projects are subject to peer evaluation
- Only those projects evaluated as good, very good, or excellent are considered for funding
- A committee evaluates the project pertinence
  - intrinsic relevance of the proposal, its possible impact on the socioeconomic development of the country or region, and on the training of human resources
- The order of merit was: excellent, very good, and good projects of high pertinence; excellent and very good projects of medium pertinence; and excellent projects of low pertinence

Data

- We have yearly data on academic outputs for the period 1994 to 2004 corresponding to the main researcher of the project
- All researchers in our database applied for a FONCYT subsidy in the years 1998 and 1999, which means that we have information before and after the subsidy
- The sample includes 218 funded projects and 105 non-funded projects
- All projects were approved for funding (were evaluated as good, very good, or excellent) though some of them were not supported due to scarcity of resources

The academic outcomes

- Our main measure for academic output is the number of publications
  - This is the measure used by CONICET to evaluate its researchers
- A potential bias would arise if the increase in the number of publications occurs at the expense of a loss in its academic quality
- To account for this concern we also include as an additional academic output the sum of the impact factor of publications

Researcher and project characteristics

- The database includes the average peer review score received by the proposals, the researchers' age, whether researcher has a doctorate, a dummy variable that takes the value of one for male researchers, a dummy variable that takes the value of one if the researcher is part of a group that was constituted after 1994, a dummy variable that takes the value of 1 if the researcher works at a private institution, and a set of dummy variables for the region, year in which the subsidy was granted, and project field
- We do not have data on the pertinence of the project

Summary statistics

	FONCYT = 0 *105 observations*		*FONCYT = 1* *218 observations*	
Variable	Mean	Standard Deviation	Mean	Standard Deviation
Publications Pre-Treatment	1.07	1.76	1.74	2.01
Publications Post-Treatment	1.02	1.09	1.94	2.02
Impact Factor Pre-Treatment	1.49	2.96	3.13	4.49
Impact Factor Post-Treatment	1.79	2.51	4.05	5.03
Peer-Review Evaluation	6.83	0.79	8.28	0.97
Field-Biomedical Sciences	0.37	0.49	0.38	0.49
Field- Exact Sciences	0.16	0.37	0.17	0.37
Field-Technologies	0.47	0.50	0.45	0.50
New Group	0.50	0.50	0.41	0.49
Gender	0.63	0.49	0.66	0.48
Age (as of 2005)	56.72	8.65	55.00	8.18
Doctorate	0.77	0.42	0.84	0.36
Private Institution	0.03	0.17	0.02	0.14

Identification strategy

- In an experimental setting both observed and unobserved characteristics would be balanced across successful and unsuccessful applicants
  - One could identify the causal effect of receiving a grant by simply comparing the academic output of those that received and did not receive the grant
- The allocation of grants, however, is not random
  - Funding is likely to be positively correlated with observed and unobserved characteristics, such as motivation
  - If this were the case, the simple comparison of the academic output of successful and unsuccessful applicants would be biased upwards

Identification strategy

- A usual approach to deal with non-experimental data is to estimate a difference-in-differences model

$$Y_{it} = \beta D_{it} + \lambda X_{it} + \alpha_i + \mu_t + \varepsilon_{it} \qquad (1)$$

where Y_{it} is the research output of applicant *i* in time *t*, D_{it} is a dummy variable that takes the value of one if applicant *i* receives the grant in time *t*, β is the parameter of interest, and X_{it} is a vector of time-variant observable determinants of output. The unobservable determinants of research output are reflected in the last three terms. There is a time-invariant 'applicant effect' (α_i), a time-period effect common to all applicants (μ_t), and the usual error term (ε_{it}).

Identification strategy

- In the difference-in-differences model it is not necessary to control explicitly for time invariant researchers' characteristics since these characteristics are absorbed by the individual fixed effects
- These approach, however, may not completely eliminate time-varying unobserved heterogeneity

Main assumption

- The difference-in-differences estimator assumes that the change in academic output for control researchers is an unbiased estimate of the counterfactual
- We cannot test this assumption directly
- But we can test whether the trends in academic outcomes were the same for treated and controls before the treatment

Figure 1. Trends in the number of publications

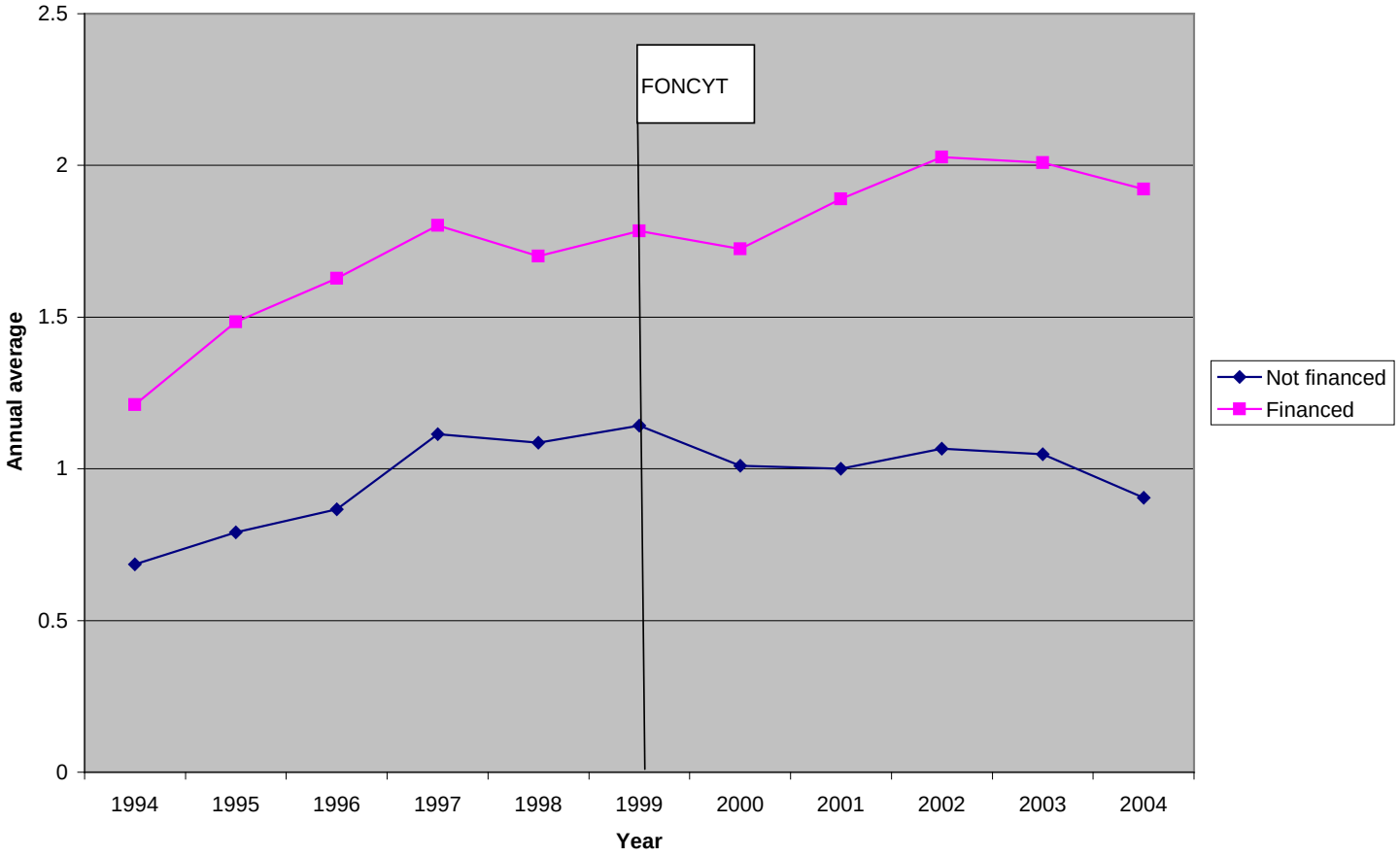
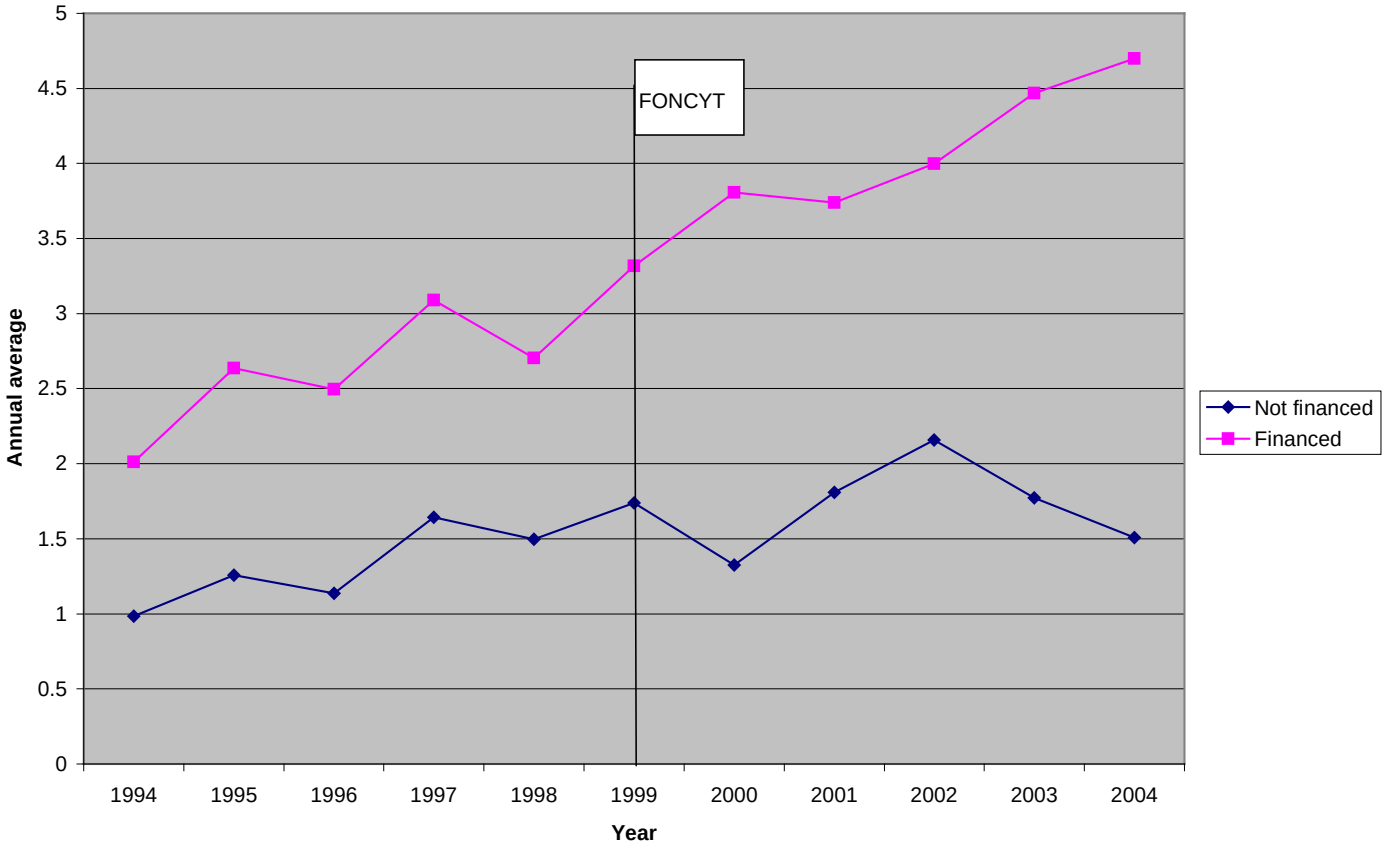


Figure 3. Trends in the quality index of publications.



Difference-in-differences estimates

	Publications				Impact Factor			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Foncyt	.195	2.436	.214	2.442	.911	4.219	.726	5.548
	(.086) **	(.450) ***	(.111)*	(.573)***	(.207)***	(1.18)***	(.252)***	(1.53)***
	[.106]*	[.487]***	[.136]	[.701]***	[.255]***	[1.29]***	[.314]**	[1.65]***
Age		.042		0.035		0.136		0.164
		(.011)***		(.015)**		(.033)***		(.041)***
		[.013]***		[.016]**		[.038]***		[.049]***
Foncyt*		-.038		-.035		-.071		-.085
Age in 2005		(.007) ***		(.009)***		(.019)***		(.025)***
		[.008]***		[.010]***		[.021]***		[.026]***
Foncyt*		.013		-.108		.763		.369
Doctorate		(.112)		(.141)		(.275)***		(.341)
		[.137]		[.172]		[.312]**		[.380]
Foncyt*		-.175		-.319		-.031		-.658
Gender		(.118)		(.148)**		(.310)		(.385)*
		[.158]		[.202]		[.373]		[.450]
Sample	3549	3549	2308	2308	3548	3548	2309	2309
R-squared	0.627	0.631	0.661	0.664	0.533	0.536	0.504	0.509

Notes: all regressions include researcher fixed effects and time dummies. Heteroskedasticity robust standard errors are shown in parentheses. Standard errors clustered at the researcher level are shown in brackets. Results in Columns (3), (4), (7), and (8) use the sample restricted to common support. *Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level.

Diff-in-diff in common support

- One important source of bias in the difference-in-differences approach could arise if there are no comparable control researchers for some funded researchers and vice versa
- We deal with this potential source of bias by applying the difference-in-differences approach to the common support
  - We first estimate the propensity scores by means of a probit regression of the probability of being funded on a number of pre-treatment characteristics such as Peer Review Evaluation, Age, Gender, Doctorate, New group, Publications, Impact, and a set of indicator variables for region and scientific area
  - Then the common support is obtained by excluding observations from control researchers with an estimated propensity score smaller than the minimum estimated for the treated group, and observations from treated researchers with an estimated propensity score larger than the maximum estimated for the control group

Robustness check

- In order to further check the robustness of our results we use a difference-in-differences matching estimator
- And we try an alternative definition of the common support
  - In the alternative definition the common support is obtained excluding the observations from control researchers whose propensity scores are less than the propensity score of the researcher at the first percentile of the treatment propensity score distribution and excluding funded researcher's observations whose propensity score is greater than the propensity score of the control observation at the ninety-ninth percentile of the control distribution

Difference-in-differences matching estimates

	Publications		Impact Factor	
	(1)	(2)	(3)	(4)
	136 treated and 74 controls	215 treated and 87 controls	136 treated and 74 controls	215 treated and 87 controls
Kernel matching[a]	0.797*	0.967**	1.06	1.446*
	(0.472)	(0.478)	(0.893)	(0.858)
Radius matching[b]	0.677*	0.835**	0.924	1.32*
	(0.376)	(0.379)	(0.754)	(0.671)

Notes: bootstrapped standard errors (500 replications) are shown in parentheses.
In Columns (1) and (3) the common support is obtained excluding observations from control researchers with an estimated propensity score smaller than the minimum estimated for the treated group, and observations from treated researchers with an estimated propensity score larger than the maximum estimated for the control group. In Columns (2) and (4) the common support is obtained excluding the observations from control researchers whose propensity scores are less than the propensity score of the researcher at the first percentile of the treatment propensity score distribution and excluding funded researcher's observations whose propensity score is greater than the propensity score of the control observation at the ninety-ninth percentile of the control distribution.
[a] Gaussian kernel function with a bandwidth parameter of 0.14. [b] Radius of 0.14
*Coefficient significant at the 10% level, **significant at the 5% level.

Alternative identification strategies

- In the presence of a neat cutoff we could have used a sharp regression discontinuity design
- And with a higher correlation between the peer-review evaluation score and FONCYT we could have used a fuzzy design

Some caveats in the interpretation of the results

- First, our difference-in-differences estimation strategy assumes
  - That in the absence of the program there are common time effects for treated and control researchers, and
  - That any difference in academic outcomes across treated and control researchers due to unobserved factors is fixed over time
- Second, the reported estimates cannot answer the question of how the FONCYT grants affect academic productivity of successful applicants relative to receiving no support. They only capture the impact of receiving the FONCYT grant relative to the next best funding option
  - Having said this, while in developed countries researchers have many alternatives for research funding, in Argentina the alternative option might be no funding at all
- Finally, more research is needed for fully evaluating the impact of this kind of subsidies. In particular, for a full evaluation of the cost effectiveness of a public program like FONCYT it is important to consider potential externalities generated by the research project and the alternative use that could have been given to public funds

Conclusions

- Taking the above caveats into account, our results suggests that research funding improves the academic performance of supported researchers in Argentina
- They also suggest that the effect of the subsidy is more important for young researchers
- Our results are encouraging from a policy perspective, since they suggest that funding academic research could be an effective way of promoting scientific activities in developing countries