Money for Science?
The Impact of Research Grants in Argentina

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Abstract

We evaluate the impact of subsidies on the academic performance of researchers in Argentina. Academic performance is measured in terms of number of publications and impact indexes in peer-reviewed journals. The performance of researchers with financially supported projects is compared *vis á vis* a control group of researchers who submitted projects accepted in terms of quality but not supported because of shortage of funds. We use non-experimental data and a difference-in-difference approach along with propensity-score matching techniques, where we control for pre-program observable attributes as well as time-invariant unobservable researchers' characteristics. Our findings suggest a positive and statistically significant effect of the subsidy on academic performance, especially on young researchers.

JEL classification: H50.

Keywords: scientific research, program evaluation, propensity score matching, Latin America, Argentina.

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1. Introduction

As the seminal articles by Nelson (1959) and Arrow (1962) showed many decades ago scientific knowledge, the product par excellence of scientific research, may be conceived as a durable public good: the exclusion of its use is expensive, non-rival, and cumulative. Non-perfect exclusion generates a difference between the private marginal return and the social marginal return with the consequent underinvestment in non-regulated markets. The non-rival and cumulative character intensifies the difficulty to compensate for the non appropriable profits, causing a greater sub-optimality in the allocation of resources. This sub-optimality is further increased due to the uncertainty and to the indivisibilities associated to the investments in knowledge. Thus, 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.

There are few studies that have analyzed the impact of public funding on scientific research, and all of them 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, but they do not find a significant impact for NIH research grants.[1] Finally, Goldfarb (2001) measures the impact of a NASA aerospace engineering program and finds a positive effect on the

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[1] Pion (2001) finds that NIH pre-doctoral support has no impact on publications and citations of funded students compared to other doctoral students, and a low positive impact in their future careers. In the same direction, Carter, Winkler and Biddle (1987) find a non significant effect of NIH career development awards on publication-based measures of research productivity.

number of publications, though there is evidence that higher quantity was achieved at the expense of the quality of publications.

Our study contributes to this literature by evaluating econometrically, for the first time to our knowledge, the impact of scientific research grants on academic performance in a developing country. In particular, we study the impact that the subsidies granted by the Fund for the Scientific and Technological Research (FONCYT) have had on the academic performance of supported researchers in Argentina.

Researchers in developing countries face more difficult constraints for undertaking scientific activity than those in developed countries, which underscores the relevance of public funding programs. In developing countries the existence of private mechanisms of funding for science is lower than in developed countries, while the infrastructure conditions for scientific research (as well as the access to inputs and specialized publications) are often poor due to budget restrictions.

The plan for the remainder of the paper is as follows. Section 2 introduces some general data on Argentina's science and technology capabilities and explains the main features of FONCYT subsidies' program. The database is described in section 3. The methodology and results are presented in section 4. Finally, some concluding comments are made in section 5.

2. The FONCYT: a brief description

Argentina's level of expenditure in Research and Development (R&D) activities amounts nearly 0.5% of its GDP. This is a low level when compared not only with developed countries (where often more than 2% of GDP is devoted to R&D) but also with some neighbor developing countries such as Brazil (0.9%) or Chile (0.6%).

An increasing part of the funds available for R&D activities in Argentina comes from the National Agency of Scientific and Technological Promotion (ANPCYT), created in the mid 1990s. The ANPCYT administers two funds, the Argentine Technological Fund (FONTAR) which gives credits and subsidies to technological projects, and the FONCYT, which is dedicated 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 activities of the FONCYT began in 1997. One of the objectives of its creation was to develop an instance of public funding of science on the basis of competitive mechanisms, based on the quality evaluation through peer review and pertinence criteria.[2] In this paper we evaluate the impact of the Scientific and Technological Research Projects (PICT) funded by FONCYT in 1998 and 1999.

The PICTs represented almost 75% of all the funding granted by the FONCYT from 1998 to 2004 and include four different categories of projects. The first one is for research projects in all areas of scientific and/or technological knowledge. The second category is for research projects on sectors and specific topics,[3] whereas the third one is targeted to research projects in priority regions. Finally, there is a category for projects co-financed within the framework of agreements with public and private organizations or companies.

The projects are divided according to the experience of the group of researchers, distinguishing consolidated groups from groups of recent formation –after 1994, according to the rules of the program. The maximum amount of subsidy was $50,000 per year, for a maximum of three years.

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[2] 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 that started to operate in 1958 and that is based on the formula of a “career researcher” by which scientists are permanent staff of the Federal Government.

[3] The priority areas are: Agroindustrial Production, Mining, Education, Health, Natural Resources and Environment, Biotechnology, Argentinean Sea, Manufacturing Industry, Energy, Defence, Clean Technologies, Ozone and Climate Change, Biodiversity, Microelectronic Applications, National System of Innovation Studies, Violence and Urban Security, and Gender Studies.

With the subsidy of the FONCYT it is possible to fund inputs, purchase of bibliography, publication edition, scholarships, trips to participate in scientific conferences, specialized technical services, and equipment. The salaries of the researchers are not fundable. A requisite to receive the subsidy is to count on a permanent source of income from the institution in which the researcher works.

The selection process of the projects to be funded can be summarized in three steps. The first one involves admissibility. In this stage it is verified that the projects fulfill the minimum requirements that constitute the admission criteria.[4] Once the project is admitted, the following step is the peer evaluation of its quality. Only those projects evaluated as good, very good, or excellent are considered for funding. The final step is the evaluation of 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 for the projects in condition of being funded was the following one: excellent, very good, and good projects of high pertinence, excellent and very good projects of medium pertinence, and excellent projects of low pertinence.

3. 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.

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[4] The minimum requirements are that the researchers of the group (i) have a labour relationship with an Argentine institution of science and technology, (ii) dedicate a minimum of 50% of their time to the execution of the project, and (iii) have previous experience in academic research.

Our measures for academic output are the number of publications (Publications) and the impact index of publications (Impact). Data on publications and impact indexes were collected from the Science Citation Index. We consider, as the performance variable, the number of publications or the impact index of publications of the researcher who is in charge of the project.

The database also includes the average peer review score received by the proposals (Peer-Review Evaluation), the researchers' age (Age), a dummy variable that takes the value of one if the researcher has a doctorate (Doctorate), a dummy variable that takes the value of one for male researchers (Gender), a dummy variable that takes the value of one if the researcher is part of a group that was constituted after 1994 (New group), a dummy variable that takes the value of one if the researcher works at a public non-profit institution (Public Institution), and a set of dummy variables for the region, year in which the subsidy was granted, and project field. There are twelve fields that we have grouped in three broadly defined areas: Biomedical Sciences (Biological Sciences and Medical Sciences), Exact Sciences (Physical and Mathematical Sciences, Chemical Sciences, and Earth and Hydro-atmospheric Sciences), and Technologies (Food Technology, Agricultural, Forestry, and Fishing Technology, Information Technology, Electronic and Communication Technology, Mechanic and Material Technology, Environmental Technology, and Chemical Technology). We do not have data of pertinence of the project. Summary statistics are presented in Table 1.

Table 1 – Here

4. Methodology and results

We are interested in estimating the impact of research grants on academic productivity. In an experimental setting in which research grants were randomly allocated to researchers, unobserved characteristics would be balanced across successful and unsuccessful applicants, and 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, implying that funding is likely to be positively correlated with 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.

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 $\left(\varepsilon_{it}\right)$.

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. The difference-in-differences approach proposed here, however, may not completely eliminate time-varying unobserved heterogeneity and thus our estimates should considered upper bounds of the causal effect.

The difference-in-differences estimator assumes that the change in academic output for control researchers is an unbiased estimate of the counterfactual—i.e., the change in academic output for funded researchers had they not been funded. 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 already suggests similar trends before treatment. To formally test this hypothesis we estimate a model like the one in Equation (1) but excluding the treatment dummy variable and including separate year dummies for (eventual) treatments and controls (see Galiani, Gertler, and Schargrodsky, 2005). We cannot reject the hypothesis that the pre-intervention year dummies are the same for (eventual) treated and control researchers, a result that validates our difference-in-differences identification strategy.[5]

Figure 1 – Here

Figure 2 – Here

Figure 3 – Here

Results corresponding to the difference-in-differences model are reported in Table 2. A typical concern when using difference-in-differences is the potential problem of serial correlation, which results in biased standard errors and generates over-rejection (Bertrand, Duflo, and Mullainathan, 2004). In order to address this concern we report standard errors clustered at the researcher level.

Table 2 - Here

In Column (1) we report difference-in-differences estimates without controls. In this specification the coefficient associated to FONCYT is positive and statistically significant. Comparing the five-year window pre- and post-subsidy, the difference is about one article. In another specification (not shown) we explore the evolution of academic output over time and we find that most of the impact occurs three years after receiving the grant.[6]

In Column (2) we present a model including researcher's age and interaction terms as additional regressors. The coefficient for age is positive and significant. The coefficient of the interaction term between FONCYT and Age (as for 2005) is statistically significant, and its value suggests that the impact of FONCYT is more important for young researchers. This is in line

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[5] Figure 3 suggests a similar pattern when considering the quality index of publications. We also present, in Figure 2, the trends of treatment and control groups for 'young' and 'old' researchers separately.

[6] All results mentioned but not shown are available from the authors upon request.

with Arora and Gambardella (2006), who find that the impact of a National Science Foundation grant is strongest for junior researchers. We do not find significant differentiated effects by gender or doctoral education. In other specifications (not reported) we also show that there are no differentiated effects by scientific areas or peer review score received by the proposals.

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.[7] 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.[8] As shown in Columns (3) and (4), results corresponding to the difference-in-differences in the common support approach are consistent with previous results.

A potential bias would arise in our previous specifications if the quality of publications were correlated with FONCYT. For example, if the increase in the number of publications occurs at the expense of a loss in its academic quality, then the coefficient on FONCYT would overestimate the impact of the program. In Columns (5) to (8) we report results using the sum of the impact index of publications as the measure of academic output. Results using impact indexes are similar to those using publications, thus providing additional evidence that the FONCYT

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[7] The probit model satisfies a series of balancing tests—it balances the distribution of pre-treatment covariates for matched researchers once we condition on the propensity score (Rosenbaum and Rubin, 1985; Lechner, 2000).

[8] We use other definitions for the common support, with similar results.

subsidy had a positive impact on the academic performance of funded researchers. Interestingly, the interaction term between doctorate and FONCYT becomes positive and significant when we use impact indexes, suggesting that the impact of the subsidy on the quality of research is higher for researchers with a doctorate degree.

In order to further check the robustness of our results we use a difference-in-differences matching estimator (see Heckman, Ichimura, and Todd, 1998; Todd, 2006), and we obtained similar results (see Table 3).

Table 3 - Here

5. Conclusion

We evaluate the impact of FONCYT subsidies on academic performance of Argentine researchers. The performance of researchers with supported projects is compared *vis á vis* a control group constructed using researchers that submitted projects accepted in terms of quality but not supported because of unavailability of funds. We find a positive and statistically significant effect of the subsidy on the number of publications. Thus, our empirical evidence suggests that research funding improves the academic performance of supported researchers in developing countries.

In economic terms, our results indicate that approximately 110,000 argentine pesos (seven times Argentina’s GDP per capita) are needed in order to get a researcher subsidized by FONCYT to publish, in a five-year window, one more paper than a non-funded researcher.

We also find that the effect of the subsidy is more important for young researchers. As explained above, before the existence of FONCYT the main source of funds for science in Argentina was the CONICET, an organization in which researchers make a “career” and that is characterized by heavy bureaucratic and hierarchical norms. Hence, it is not surprising to find that FONCYT subsidies have been especially relevant for young researchers, who may find difficult the access to funds for their own research projects through the CONICET.

We have done a number of robustness checks. The significant positive impact of FONCYT on academic performance persists when academic output is measured in terms of the quality of publications, rather than the number of publications. We also address the problem of selection bias via several approaches including difference-in-differences in common support and propensity score matching. In all cases we find a positive and significant impact of the program on academic performance.

Some caveats are needed in the interpretation of the results. First, our difference-in-differences estimation strategy assumes (i) that in the absence of the program there are common time effects for treated and control researchers, and (ii) that any difference in academic outcomes across treated and control researchers due to unobserved factors is fixed over time. The impact estimator could be bias if any of these assumptions do not hold.

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 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.

Taking these caveats into account, 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.

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Table 1. 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 Index Pre-Treatment	1.49	2.96	3.13	4.49
Impact Index 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
Public Institution	0.03	0.17	0.02	0.14

Table 2: Difference-in-differences estimates

	Publications				Impact Index			
	(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.

Table 3: Difference-in-differences matching estimates

	Publications		Impact Index	
	(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* (0.472)	0.967** (0.478)	1.06 (0.893)	1.446* (0.858)
Radius matching[b]	0.677* (0.376)	0.835** (0.379)	0.924 (0.754)	1.32* (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.

Figure 1. Trends in the number of publications

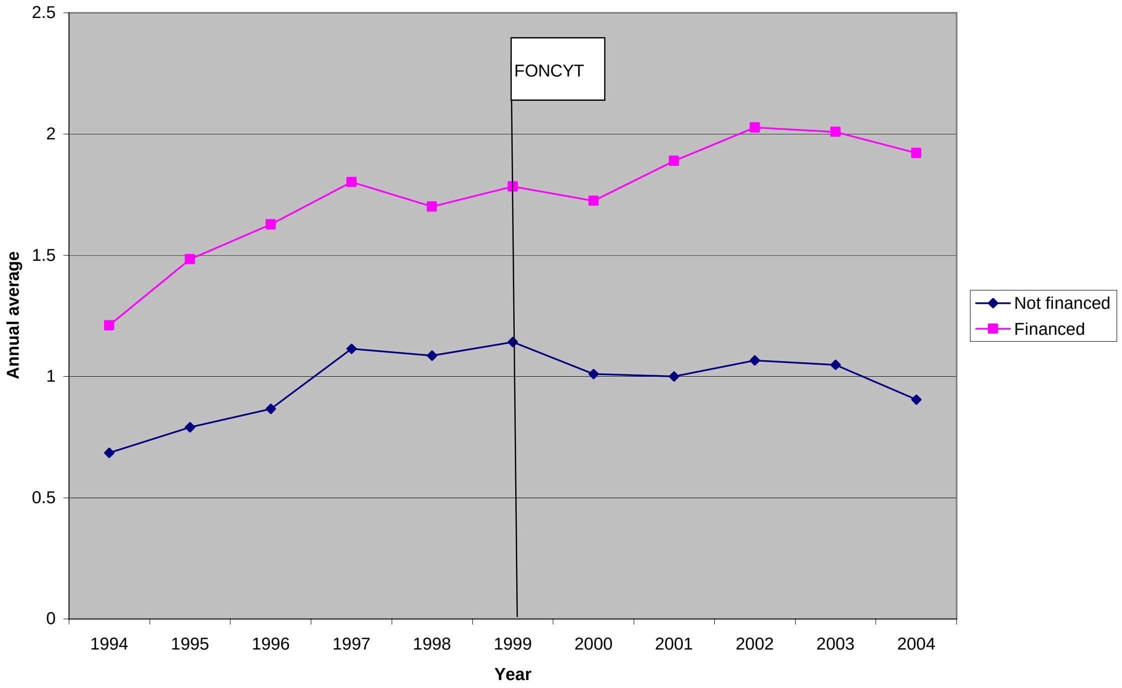
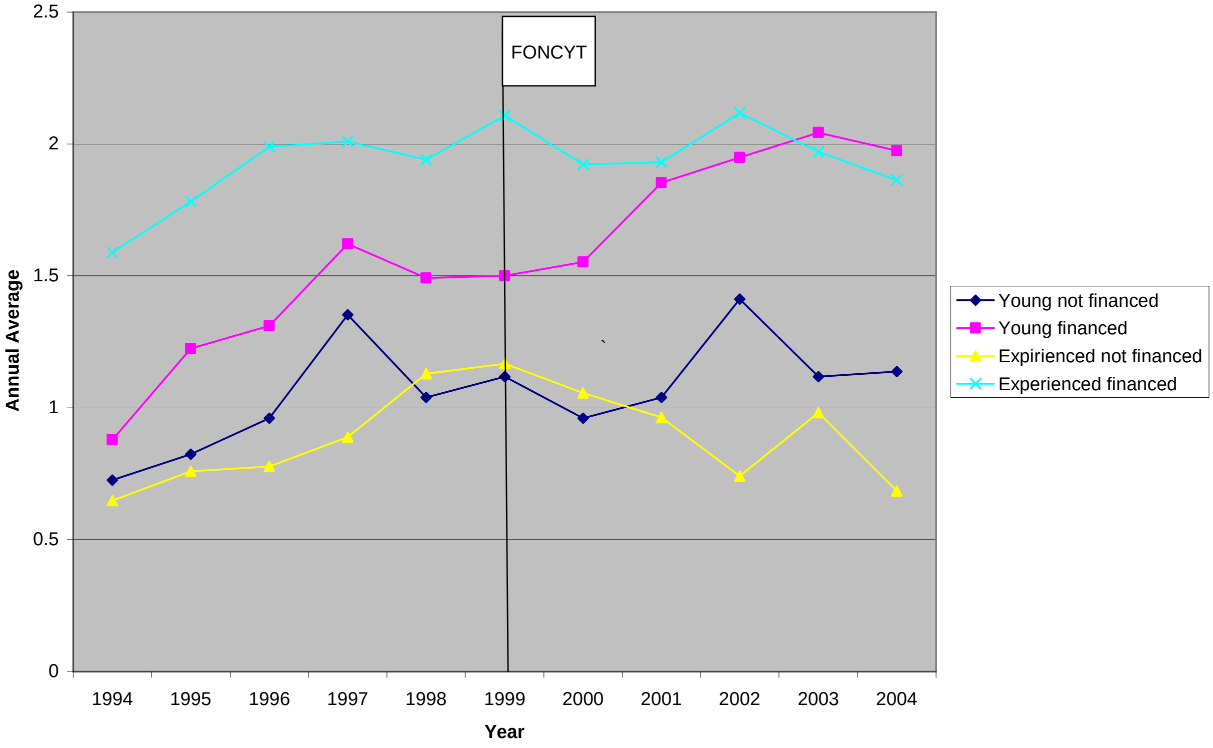


Figure 2. Trends in the number of publications by age



Note: researchers were divided into the "young" and "experienced" groups using the median pre-treatment age of the researchers that received the treatment (54 years) as the cut-off point.

Figure 3. Trends in the quality index of publications.