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**Douglas Campbell¹, Abel Brodeur², Magnus Johannesson³,
Joseph Kopecky⁴, Lester Lusher⁵, Nikita Tsoy⁶**

¹New Economic School, Moscow/Russia

²University of Ottawa/Canada and IZA – Institute of Labor Economics, Bonn/Germany

³Stockholm School of Economics, Stockholm/Sweden

⁴Trinity College Dublin/Ireland

⁵University of Pittsburgh/USA

⁶Institute for Computer Science, Artificial Intelligence and Technology (INSAIT), and Sofia University, Sofia/Bulgaria

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Editors

Abel Brodeur
University of Ottawa

Anna Dreber
Stockholm School of Economics

Jörg Ankel-Peters
RWI – Leibniz Institute for Economic Research

E-Mail: joerg.peters@rwi-essen.de
RWI – Leibniz Institute for Economic Research

Hohenzollernstraße 1-3
45128 Essen/Germany

www.i4replication.org

Robustness Report on “Innovation and Institutional Ownership”, by Aghion, Philippe, John van Reenen, and Luigi Zingales (2013).*

Douglas Campbell[†] Abel Brodeur[‡] Magnus Johannesson[§]

Joseph Kopecky[¶] Lester Lusher^{||} Nikita Tsoy^{**}

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Abstract

[Aghion, Van Reenen and Zingales \(2013\)](#) find that institutional ownership causes an increase in innovation as measured by citation-weighted patent counts. To identify a causal effect, they use membership in the S&P 500 as an instrument for institutional ownership in a panel regression. We first replicate all regression tables in Aghion et al., and then test for robustness, mainly by adding in firm and sector*year fixed effects. We find that the positive relationship between institutional ownership and innovation is robust in 22% of robustness checks. On average, 2nd stage z-scores were just 42.7% of the original study. We find that when we include firm fixed effects, membership in the S&P 500 actually has a negative (though significant only at the 10% level) impact on institutional ownership (among non-indexed funds). Lastly, we find that the original control-function IV regression suffers from multi-collinearity, complicating inference.

JEL Classification: G23, G32, L25, M10, O31, O34

Keywords: Innovation, Patents, Institutional Investment

*This robustness report was written as part of a meta-robustness project entitled “The robustness reproducibility of the American Economic Review”. See [Campbell, Brodeur, Dreber, Johannesson, Kopecky, Lusher and Tsoy \(2024\)](#) for more information.

[†]Corresponding author. New Economic School, E-mail: dolcampb@gmail.com

[‡]University of Ottawa and IZA. E-mail: abrodeur@uottawa.ca

[§]Department of Economics, Stockholm School of Economics, E-mail: magnus.johannesson@hhs.se

[¶]Department of Economics, Trinity College Dublin, E-mail: jkopecky@tcd.ie

^{||}Department of Economics, University of Pittsburgh, E-mail: lesterlusher@pitt.edu

^{**}INSAIT, Sofia University, E-mail: nikita.tsoy@insait.ai

1 Introduction

[Aghion et al. \(2013\)](#) – hereafter AvRZ – find that institutional ownership of stocks causes an increase in innovation, as measured by citation-weighted patents. To achieve identification, they use membership in the S&P 500 as an instrument for institutional ownership in a panel regression. Additionally, they find that quasi-indexed institutional investment has no correlation with innovation, while other institutional investment (not-quasi indexed) is positively associated with innovation. This evidence fits their theory that the impact of increased monitoring that discerning non-quasi-indexed institutional investment brings has an immediate and large positive impact on innovation, while less-discerning indexed institutional investment has no impact.

We first computationally reproduce all the regression tables in AvRZ, and find that we are able to reproduce their results exactly using the data and code provided by the authors via the AER website. Then we then run a number of robustness checks on what we view as the key identified result. These robustness checks include adding in firm and sector*year interactive fixed effects and using institutional ownership of non-quasi-indexed funds as our key variable of interest instead of all institutional funds. Additionally, we run a standard IV instead of a control-function IV, a robustness check that AvRZ also implement, only we add fixed effects, necessary in our view in this difference-in-difference panel setting.

First, we find that the positive impact of institutional ownership on innovation is robust at a 5% confidence level in only 22% of robustness checks. On average, we find 2nd stage z-scores were just 42.7% of the original study. However, we also find that the original control function IV approach suffers from a multi-collinearity problem which complicates inference. Among the robustness checks, we prefer those that include firm fixed effects, as panel and time fixed effects are standard in difference-in-differences estimation. When we do so, none of the five robustness checks we ran are significant at the 5% level. It's noteworthy that when we use a model

with firm fixed effects we find that S&P 500 membership actually reduces non-quasi institutional investment (i.e., the sign of the first stage flips), albeit with significance only at 10% level of confidence, and the second stage is also now negative but not statistically significant at conventional levels.

2 Replication

2.1 Regression model

We chose AVrZ (2013) Table 5, column (6) as the main benchmark result we will test robustness for.[§] We adopt the same empirical specification as AVrZ (2013), using an identical control function instrumental variable. Note that while the exact regression equations were not provided by AVrZ (2013), we provide them here for purposes of clarity. In the first stage, the share of institutions (that is, the share of each firm which is owned by institutional investors) is the dependent variable, and a dummy variable for membership in the S&P 500 is the instrumental variable.

$$INSTIT_{ijt} = \beta_1 S\&P500_{ijt} + \beta_2 \ln(CapitalperWorker)_{ijt} + \beta_3 \ln(Sales)_{ijt} + \beta_4 \ln(InitialCitations)_i + \beta_5 InitialCitationDummy_i + \tau_t + \zeta_j + \epsilon_{ijt} \quad (1)$$

The dependent variable here, $INSTIT_{ijt}$ is the share of institutional investment in firm i , sector j , and year t . τ_t are year fixed effects, ζ_j are sectoral fixed effects at the 4-digit SIC level, and ϵ_{irt} are the first stage error terms. “Initial Citations” are the average number of firm-level citation-weighted patents in the period before the panel regression begins (the period is 1991 to 1999).

The authors use a control function IV approach, which means that they then use the first-stage residuals as a control in the second-stage poisson regression. In the

[§]Note that we chose this regression as (1) it uses causal identification, (2) is significant at a 95% level of confidence (note that Table 4, column 7 also uses causal identification, but the key coefficient is already not significant at a 95% level), and (3) the other regressions in Table 5 which also use causal identification are similar but lack “controls for firm fixed effects”, which are necessary in this case, in our view.

2nd stage, the dependent variable is citation-weighted patents, with institutional ownership included as a (potentially endogenous) control, with the endogenous portion controlled for via the first-stage residuals.

$$\begin{aligned}
 CITES_{irt} = & \exp(\alpha INSTIT_{ijt} + \beta_1 \epsilon_{ijt} + \beta_2 \ln(CapitalperWorker)_{ijt} + \\
 & \beta_3 \ln(Sales)_{ijt} + \beta_4 \ln(InitialCitations)_i + \beta_5 InitialCitationDummy_i + \tau_t + \zeta_j + \nu_{ijt})
 \end{aligned}
 \tag{2}$$

The second stage is estimated via a poisson regression, as the citation-weighted patents are count data with a mass at zero. The idea is that including the first-stage residuals will purge the regression of endogeneity.

2.2 Computational Reproduction

We first completed computational reproduction for all the regression tables in this paper, and, using the author-provided data and code, were able to reproduce the original results exactly.[§] In this note, we simply show the exactly replicated results of AVrZ Table 5, columns (5) and (6) in our [Table 1](#), columns (1) and (2). We additionally provide the coefficient and p-value for the first-stage residuals, which were included as a control in the original paper but not reported in AvrZ's Table 5. What we see is that, in this case, the first stage residuals and the share of institutions increase in magnitude from the OLS estimate provided by AzRZ (.007) but are of the opposite sign, suggestive of multicollinearity.

2.2.1 Multicollinearity

Given the potential for multicollinearity in the second stage control function regression, we computed the correlation between institutional investment and the first

[§]Note that this study was not pre-registered. We implemented the computational reproduction before designing the robustness plan, and our study gives full leeway to the replicators to add more robustness checks after coming in contact with the data and writing our initial robustness proposal. All robustness checks run on the paper's key results are recorded here. We also found that other tables in the paper were also sensitive to the addition of fixed effects, but these other tables are either not causally identified or not statistically significant at a 5% level of confidence to begin with and thus are omitted here.

stage residuals at .79, and the variance inflation factor (VIF) of the share of institutions at 296. Note that a variance inflation factor above 10 is generally thought to be a problematic indicator of multicollinearity. Given this, a straightforward interpretation of the magnitude on the coefficient on the share of institutions is probably not warranted, and the multicollinearity problem might account for the dramatic increase in the coefficient compared to the poisson regression run in Table (5), column (4) of AvRZ (.007 vs. .029) that does not include the first stage residuals.

2.3 Robustness

We report our first robustness results in Table 1. In columns (3) and (4), we add in firm fixed effects. This is an interesting control, as we would like to see the impact of S&P 500 membership on a particular firm before and after joining relative to other firms that did not join. Including firm fixed effects allows us to make exactly this comparison. Table 5 notes in AvRZ states that the authors include “Fixed effects”, but the table notes indicate that the fixed effects are included by way of one of the author’s own methods, which in this case is controlling for the pre-sample mean in patent citations and a dummy variable for whether initial patents are greater than zero. In this case we find out that this method turns out not to be equivalent to conventional fixed effects, particularly in the first stage OLS regression. The first stage coefficient falls from 8.87 to 2.5 in column (3) when we include actual firm fixed effects, and the first stage t-value falls from 3.77 to 1.21, indicating a weak instrument. The second stage coefficient rises to .14 from .029, but the t-value falls to 1.82, the coefficient is no longer significant at 5%, and the multi-collinearity problem worsens, again complicating inference. In Table 1 columns (5) and (6), we add in four-digit SIC industry*year interactive fixed effects, and drop the firm fixed effects. We get a second-stage t-value of 1.88. Next, in Table 2, columns (1) and (2), we add in both firm and four-digit SIC industry*year interactive fixed effects. This time our second stage t-value falls to .68, and the coefficient on the share of

institutions is no longer significant even at 10%.

Table 1: Table 5, Col. (5) & (6): Replication & Robustness

	(1)	(2)	(3)	(4)	(5)	(6)
	Instit.	Cites	Instit.	Cites	Instit.	Cites
	b/se/t/p	b/se/t/p	b/se/t/p	b/se/t/p	b/se/t/p	b/se/t/p
S&P 500	8.872		2.502		8.832	
	(2.35)		(2.06)		(2.63)	
	[3.77]		[1.21]		[3.36]	
	{0.000}		{0.226}		{0.001}	
Share of Institutions		0.0286		0.138		0.0247
		(0.013)		(0.076)		(0.013)
		[2.16]		[1.82]		[1.88]
		{0.031}		{0.068}		{0.060}
1st Stage Residuals		-0.0235		-0.138		-0.0187
		(0.014)		(0.075)		(0.014)
		[-1.71]		[-1.84]		[-1.38]
		{0.087}		{0.066}		{0.168}
Observations	6208	6208	6208	6208	6208	5422
Added FEs	None	None	Firm	Firm	SIC*Year	SIC*Year

Notes: Errors clustered at the firm level. This table first replicates Table 5, columns (5) and (6) of AvrZ, and then tests robustness by adding in firm FEs and then SIC Industry*year interactive FEs. Columns (1), (3) and (5) are the first-stage regressions, and the dependent variable is the share of institutions. Columns (2), (4), and (6) are 2nd stage poisson regressions using a control function IV, and the dependent variable is citation-weighted patents.

AVrZ argue that the effect of institutional ownership should in theory be larger for funds that are not quasi-indexed to the S&P 500. They also present evidence that the effect only exists for non-quasi-indexed funds. Thus, in the next robustness test, we replace the institutional share with the share of non-quasi-indexed institutional funds. In this case, running AVrZ's original model without firm or industry*year fixed effects, we get an identical coefficient, but with much larger standard errors, and a p-value of .67 vs. .031 in the original regression. When we add in firm fixed effects (in Table 3 column 1), the sign on the S&P 500 dummy in the first stage flips, implying that when a firm joins the S&P 500, the share of non-quasi indexed funds actually falls. Similarly, in the second stage, we see that, now, institutional investment has a negative causal impact on innovation, albeit only with a p-value of .18. When we include sector*year interactive fixed effects, and drop the firm fixed effects, the coefficient rises, the impact is positive, and significance rises. We

also attempted to include both kinds of fixed effects (firm and sector*year), but our code was not finished running after three days and we elected to turn it off.

Table 2: Table 5, Col. (5) & (6): Additional Robustness Checks

	(1)	(2)	(3)	(4)
	Instit.	Cites	Instit.	Cites
	b/se/t/p	b/se/t/p	b/se/t/p	b/se/t/p
S&P 500	3.053 (2.55) [1.20] {0.231}		1.487 (0.62) [2.40] {0.017}	
Share of Institutions		0.0398 (0.059) [0.68] {0.500}		
1st Stage Residuals		-0.0382 (0.059) [-0.65] {0.514}		-0.0195 (0.068) [-0.29] {0.775}
Share of Non-Quasi Indexed Inst.				0.0286 (0.067) [0.43] {0.669}
Observations	6208	5400	3075	3075
Added FEs	Firm, SIC*Year	Firm, SIC*Year	None	None

Notes: Errors clustered at the firm level. This table first adds in Firm and SIC*Year interactive fixed effects to the regression from AvRZ Table 5, columns (5) and (6). The dependent variable in column (1) is the institutional share, is citation weighted patents in columns (2) and (4), and non-quasi indexed institutional investment in column (3). Columns (1) and (3) are first-stage OLS regressions, columns (2) and (4) are poisson 2nd stage regressions using a control function IV.

Table 3: Additional Robustness Checks Using Non-Quasi Indexed Funds

	(1)	(2)	(3)	(4)
	Instit.	Cites	Instit.	Cites
	b/se/t/p	b/se/t/p	b/se/t/p	b/se/t/p
S&P 500	-2.158 (1.28) [-1.68] {0.093}		3.069 (0.72) [4.26] {0.000}	
Share of Non-Quasi Indexed Inst.		-0.171 (0.13) [-1.35] {0.177}		0.0669 (0.029) [2.34] {0.019}
Residuals		0.183 (0.13) [1.45] {0.146}		-0.0521 (0.029) [-1.77] {0.076}
Observations	3075	3075	3075	2686
Added FEs	Firm	Firm	SIC*Year	SIC*Year

Notes: Errors clustered at the firm level. This table first adds in Firm and SIC*Year interactive fixed effects to the regression from AvRZ Table 5, columns (5) and (6) only using only the share of non-quasi indexed institutional investment as the dependent variable in the first stage (columns 1 and 3). The dependent variable in columns (2) and (4) is citation-weighted patents, and non-quasi indexed institutional investment in column (3). Columns (1) and (3) are first-stage OLS regressions, columns (2) and (4) are poisson 2nd stage regressions using a control function IV.

Lastly, in [Table 4](#), we run a conventional IV in a linear model, after first taking a log transformation of the patent variable. Note that doing so can lead to bias, but AvRZ do provide this version in their footnote 39. The apparent multicollinearity problem when using the control function IV version means that the alternatives to using a problematic log transformation also are not ideal. When we replicate their footnote 39, we get a coefficient of .036 (vs. .072 in the original paper), with a p-value of .015, as we have included other controls from the baseline specification, some of which were meant to “allow for firm fixed effects”. However, when we include actual firm fixed effects in column (2), the results are no longer significant. The coefficient rises again when four-digit SIC industry*year interactive fixed effects are additionally included, but in the version with firm FEs added back in, the p-value is .66.

Table 4: Log-Linear Robustness Checks w/ a Standard IV

	(1)	(2)	(3)	(4)
	Instit.	Cites	Instit.	Cites
	b/se/t/p	b/se/t/p	b/se/t/p	b/se/t/p
Share of Institutions	0.0365 (0.015) [2.45] {0.015}	0.00872 (0.087) [0.100] {0.921}	0.0383 (0.017) [2.22] {0.027}	0.0464 (0.10) [0.45] {0.656}
Observations	6208	6208	6208	6208
Added FEs	None	Firm	SIC*Year	Firm, SIC*Year

Notes: These are second-stage results only. Here the dependent variable is the log of one plus citation-weighted patents, a dummy for S&P 500 membership is the instrumental variable, and the IV is now linear. Membership in the S&P 500 is used as an instrument, and errors are clustered at the firm level.

3 Conclusion

Overall, we find that the positive impact of institutional ownership on innovation is robust at a 5% confidence level in 22% of robustness checks. On average, we find 2nd stage z-scores were just 42.7% of the original study, ranging from 1.05 (indicating a 5% larger z-score than the original study) to -.6 (indicating a different sign on the coefficient). We find that the apparent causal effect of institutional ownership on innovation weakens with the additions of firm fixed effects and sector*year interactive fixed effects. We also find that after admission to the S&P 500, while institutional ownership and innovation increase, non-quasi indexed institutional ownership, the type of ownership thought to be most conducive to innovation, actually falls. Lastly, we find that a subtle multicollinearity problem complicates inference even in the original study's preferred specification.

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