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On "Innovation and institutional ownership"☆

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ABSTRACT

In their article "Innovation and Institutional Ownership", Aghion, Van Reenen and Zingales (2013) find that the rise in institutional stock ownership in the U.S. during the 1990s led to an increase in corporate innovation, as measured by patent and patent citation counts. Their article concludes that "contrary to the view that institutional ownership induces a short-term focus in managers, we find that their presence boosts innovation" (p. 302). Subsequent research has generally accepted this finding at face value. However, we uncover several critical issues with their data. Addressing these issues renders the results economically and statistically insignificant and, in some instances, even suggests a negative relationship between institutional ownership and U.S. innovation.

1. Introduction

The rise of U.S. institutional stock ownership over the past 30 years represents one of the most relevant trends in capital market history. A central question is the impact of this shift on U.S. innovation. In an influential contribution, Aghion, Van Reenen, and Zingales (2013, hereafter AvRZ) report that the growth in institutional ownership in the U.S. during the 1990s led to an increase in corporate innovation, as measured by patent and patent citation counts.[1] However, these results are contradicted by Hirshleifer, Low, and Teoh (2012), who find a negative or no impact of institutional ownership on U.S. patents. This also counters the findings of Luong, Moshirian, Nguyen, Tian, and Zhang (2017), who determine that ownership by domestic institutions (prevalent in the U.S.) does not affect patenting outcomes. Moreover, the results challenge those of Bushee (1998) and Cremers, Pareek, and Sautner (2020), who find that ownership by short-term investors reduces U.S. firm R&D expenditures.

We identify several important issues with AvRZ's data. First, contrary to the description in their paper, we find that AvRZ include foreign firms in their sample. AvRZ use data on institutional ownership from SEC 13-F filings obtained from Compact Disclosure SEC. The inclusion of foreign firms is generally problematic when using data on 13F-filing institutional investors, particularly in this instance. The reason is that for foreign firms, institutional investors filing a 13F with the SEC represent only a minor portion of

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[1] As of November 24, 2023, the paper has accumulated over 2,280 citations according to Google Scholar and 59 policy citations as per PlumX Metrics. The policy citations include reports by the Government of Finland, the U.K. Government, the International Monetary Fund, and the World Bank (see https://plu.mx/plum/a/?doi=10.1257/aer.103.1.277).

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the total institutional ownership. Therefore, AvRZ underestimate the shares held by institutional owners in these foreign firms. In addition, institutional investors may be better positioned to monitor managers and influence innovation activities in foreign firms, creating an upward bias in institutional owners' influence when foreign firms are included. When estimating their model excluding foreign firms, there is no meaningful relationship between institutional ownership and innovation.

Second, we find significant truncation issues in AvRZ's patenting series. The AvRZ sample period is between 1991 and 1999. However, AvRZ use patents granted only until 1999, although dated by year of application, and patents weighted by future citations (with citations only up to 2002), as proxies for innovation. We contrast AvRZ's patenting series with three more recent and extended versions of the patent data. We demonstrate that the truncation bias that emerges in the AvRZ patent data is not pure noise, but is rather systematically related to institutional ownership. This makes it difficult to disentangle whether institutional ownership is truly related to innovation or whether this relationship is due to the truncation bias. When estimating their model using patent data that are less prone to truncation issues from the same sample period of AvRZ, there is no meaningful relationship between institutional ownership and innovation. When we also exclude foreign firms from the sample, we find either a negative or statistically insignificant relationship.

Abadie (2020) argues that "rejection of a point null often carries very little information, while failure to reject may be highly informative" (p. 193). However, although our results may be highly informative, two concerns need to be addressed. Specifically, our results could be due to: (i) limited statistical power, or (ii) measurement error. Regarding the first concern, we compute the minimum detectable effect size (MDES) as in Bloom (1995) for each of the ownership estimates. The MDES measures the smallest effect that, if true, could be reliably detected at a given significance level and indicates that we have sufficient power to reliably detect a meaningful relationship between institutional ownership and innovation. Regarding the second concern, Anderson and Lee (1997) show that while the ownership data from Compact Disclosure SEC rank very favorably compared to other databases, the authors report some measurement discrepancies in the number of firms' outstanding shares. To address this, we use the number of outstanding shares from CRSP. When corrected, the relationship is either negative or statistically insignificant.

We then show that AvRZ's findings regarding the interaction between institutional ownership and product market competition may also result from including foreign firms in their sample or truncation in their patenting series. When we estimate their model using the corrected data, the interaction term between institutional ownership and competition becomes statistically insignificant. Splitting the sample based on competition, the relationship between institutional ownership and innovation is very close to zero and statistically insignificant in cases of high competition. This contradicts AvRZ's career concerns interpretation. Furthermore, we find that even dedicated institutions (which are presumably long-term investors and should be more concerned about innovation than other types of institutions) show no significant association with innovation in the corrected data. Lastly, we assess AvRZ's instrumental variable approach and conclude that their instrument, the S&P 500 Index inclusion, fails the pre-test for instrument relevance. Our replication also uncovers several coding errors in AvRZ, such as the inclusion of different controls or fixed effects than those reported in their paper.

2. The AvRZ data

We use the data and replication code from AvRZ, available on the American Economic Review (AER) website (https://www.aeaweb.org/articles?id=10.1257/aer.103.1.277). The firm-level patenting variables are sourced from the 1999 National Bureau of Economic Research (NBER) match with the U.S. Patent and Trademark Office (USPTO) data. Their dataset includes patents granted between 1963 and 1999, along with all the citations made to these patents by other patents from 1975 to 2002. The patent data are then matched with accounting information from Compustat using the CUSIP identifier from the 1989 file (Hall, Jaffe, and Trajtenberg, 2001). Institutional ownership data are sourced from Compact Disclosure SEC (Compact D/SEC), an electronic version of the Form 13F that all institutional investors, who exercise investment discretion over $100 million or more in Section 13(f) securities, must file with the Securities and Exchange Commission (SEC) on a quarterly basis.[2] The data include the number of institutional owners, the number of share issues, and the percentage of outstanding shares held by each institution, which is AvRZ's key measure of institutional ownership. AvRZ note that the ownership data cover almost all firms in the Compustat-USPTO match. However, due to some inconsistencies in the ownership data reporting prior to 1991, they use data from 1991 onwards. These data are then matched with the classification of institutions in Bushee (1998), to investigate the differential effects by the type of institutional owner.

2.1. Sample composition

AvRZ assert that their sample comprises "over 800 major U.S. firms" (p. 277). Panel A of Fig. 1 shows the composition of AvRZ's sample based on each firm's country of headquarters as provided by Compustat (item: *loc*). Of the 6,208 firm-year observations spanning 803 firms in AvRZ's sample, 185 correspond to 27 foreign firms. This observation contradicts AvRZ's assertion that their sample exclusively features major U.S. firms. It is important to emphasize that subsequent research has also operated under the assumption that AvRZ's sample consisted solely of U.S. firms. For example, Luong, Moshirian, Nguyen, Tian, and Zhang (2017) cite AvRZ, mentioning that their study's motivation is drawn from AvRZ's finding that "institutional investors promote innovation in U.S. firms" (p. 1450). Similarly, Bena, Ferreira, Matos, and Pires (2017) point out that their evidence differs from AvRZ's "career concern hypothesis that explains the role of domestic institutions in corporate innovation in the U.S." (p. 124).

[2] See https://www.sec.gov/divisions/investment/13ffaq.

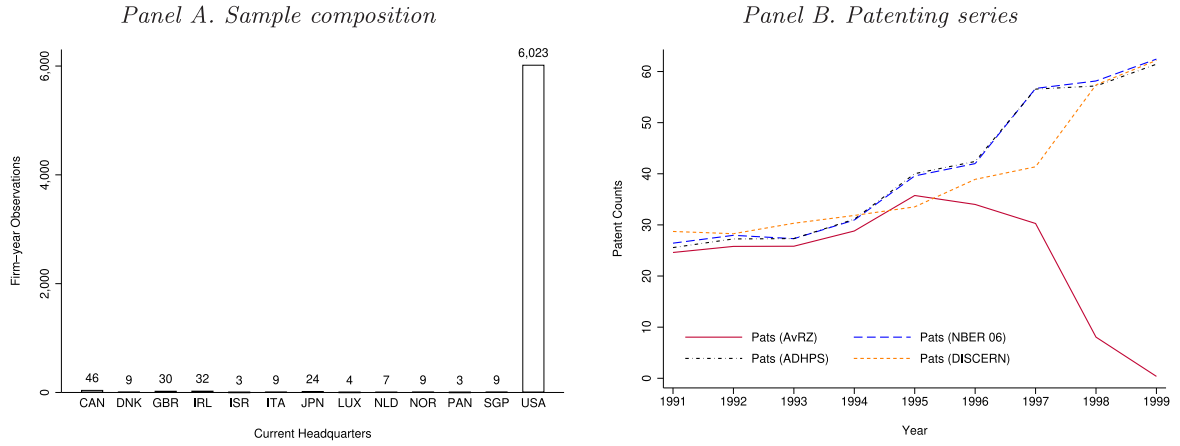

Fig. 1. AvRZ's sample composition and patenting series.
Panel A presents AvRZ's number of firm-year observations based on firms' latest headquarters location (Compustat item: *loc*). Panel B presents AvRZ's average firm patents based on the 1999 National Bureau of Economics Research (NBER) data, relative to the 2006 NBER (NBER 06) data, the Autor, Dorn, Hanson, Pisano, and Shu (2020) (ADHPS) data, and the Arora, Belenzon, and Sheer (2017) (DISCERN) data.

A limitation of the Compustat data is that it provides only the latest headquarters locations. Therefore, we supplement this data for the 27 foreign entities by using each firm's historical headquarters as provided by Bai, Fairhurst, and Serfling (2020), corporate annual reports, or corporate websites.[3] Panel A of Table 1 lists the 27 foreign firms, their countries of headquarters as provided by Compustat, and their historical countries of headquarters. We find that, among these 27 foreign firms, 19 had their headquarters already located outside the U.S. during the AvRZ sample period between 1991 and 1999. These foreign firms include notable names like Fujifilm, Hitachi, Novo Nordisk, SmithKline Beecham, and Sony. Panel A also shows an alternative data source to define non-U.S. firms, following Lang, Lins, and Miller (2003), among others. In particular, we use the Center for Research in Security Prices (CRSP) monthly files and find that all the 19 foreign firms are identified in CRSP by share code (item: *shrdc*) as firms incorporated in foreign countries (*shrdc* = 12) or American Depository Receipts (ADRs) (*shrdc* = 30 or 31).[4]

AvRZ define an institutional owner "as an institution that files a 13F" (p. 280). In the related literature, it is common practice to exclude foreign firms listed in the U.S. when analyzing institutional ownership using 13F data. In particular, firms not identified in CRSP by share code as having common stock (*shrdc* = 10 or 11) are typically excluded (see, e.g., Gompers and Metrick, 2001; Gaspar, Massa, and Matos, 2005; Chen, Harford, and Li, 2007; Yan and Zhang, 2009). This exclusion is due to the fact that, for foreign firms, institutional investors filing a 13F with the SEC represent only a minor portion of the total institutional ownership. Therefore, 13F-reported institutional holdings considerably underestimate the actual shares held by institutional investors in these foreign firms (see Ferreira and Matos, 2008).[5]

Panel B of Table of 1 provides summary statistics for the institutional ownership variable used by AvRZ for U.S. and non-U.S. firms. The difference is substantial: U.S. firms show an average institutional ownership of 46.2 and a median of 48.7, while non-U.S. firms have an average of 12.7 and a median of 6.5. Panel B also highlights important differences in the other variables used by AvRZ. For example, the average U.S. firm reports $3,295.1 million in sales, 23.5 patents, and 171.4 citations, compared to $12,642.3 million in sales, 71.1 patents, and 423.4 citations for the average non-U.S. firm.

2.2. Patenting series

Panel B of Fig. 1 shows AvRZ's patenting series. We contrast AvRZ's patenting series with three more recent and extended versions of the NBER data: the 2006 NBER (NBER 06) data, the Autor, Dorn, Hanson, Pisano, and Shu (2020) (ADHPS) data, and the Arora,

[3] The data from Bai, Fairhurst, and Serfling (2020) includes historical headquarters locations from 1969 to 2003 for firms which are in the CRSP/Compustat Merged (CCM) data. It is based on the state of headquarters from SEC filings and hand-collected historical headquarters locations from the Moody's Manuals (later Mergent Manuals) and Dun & Bradstreet's Million Dollar Directory (later acquired by Mergent). We note that of the 27 foreign firms in the AvRZ sample, 6 are included in the Bai, Fairhurst, and Serfling (2020) data. This data is available on the Review of Financial Studies (RFS) website (https://doi.org/10.1093/rfs/hhz066).

[4] We use the link history table (ccmxpf_lnkhist) to obtain CRSP's PERMNO identifiers for these firms. The table is available at the Wharton Research Data Services (WRDS) website (https://wrds-www.wharton.upenn.edu/).

[5] This underestimation is particularly pronounced for ADRs, as the U.S. tranche often represents only a small portion of the total number of shares outstanding in the company's home country. For example, Sony reported 453,639,163 shares of common stock on the Tokyo Stock Exchange (TSE) for the fiscal year ending in March 2000. Of these, 31,630,893 shares (or 6.9%) were in the form of ADRs on the New York Stock Exchange (NYSE) (https://www.sec.gov/Archives/edgar/data/313838/0000950123-98-008354.txt). The AvRZ data indicates that 3.6% of Sony's shares were held by 13F institutional investors during the fiscal year ending in March 2000. However, data from Ferreira and Matos (2008), which provides information on global institutional ownership from the FactSet/LionShares database from March 2000 onward, suggests that in March 2000, 12.3% of Sony's market capitalization was held by institutional investors.

Table 1
List of non-U.S. firms in AvRZ's sample and summary statistics.

Panel A: List of non-U.S. firms

Global Company Key	Company Name	Latest HQs	Historical HQs	Share Code
1920	AVON PRODUCTS	GBR	USA	11
8463	PENTAIR INC	GBR	USA	11
25124	PRAXAIR INC	GBR	USA	11
4199	EATON CORP	IRL	USA	11
6268	JOHNSON CONTROLS INC	IRL	USA	11
7228	MEDTRONIC INC	IRL	USA	11
13932	SAMSONITE CORP	LUX	USA	11
6509	KULICKE & SOFFA IND	SGP	USA	11
1243	ALCAN INC	CAN	CAN	12
3235	COMINCO LTD	CAN	CAN	12
4034	DOMTAR INC	CAN	CAN	12
4987	GANDALF TECHNOLOGIES INC	CAN	CAN	12
5903	IMPERIAL OIL LTD	CAN	CAN	12
5905	INCO LTD	CAN	CAN	12
6129	INTERPHARM LABS LTD	ISR	ISR	12
10243	SYNTEX CORP	PAN	PAN	12
4925	FUJIFILM HLDGS CORP	JPN	JPN	30
5650	HITACHI LTD	JPN	JPN	30
6506	KUBOTA CORP	JPN	JPN	30
8020	NOVO NORDISK A/S	DNK	DNK	31
14261	SMITHKLINE BEECHAM PLC	GBR	GBR	31
4245	ELAN CORP PLC	IRL	IRL	31
13436	MONTEDISON SPA	ITA	ITA	31
6512	KYOCERA CORP	JPN	JPN	31
9818	SONY CORP	JPN	JPN	31
15334	AKZO NOBEL NV	NLD	NLD	31
12383	NORSK HYDRO ASA	NOR	NOR	31

Panel B: Summary statistics for U.S. and non-U.S. firms

Sample	U.S. firms				Non-U.S. firms			
Variable	Mean	Median	SD	Obs.	Mean	Median	SD	Obs.
Share of institutions (in %)	46.2	48.7	22.7	6,088	12.7	6.5	16.0	120
Employees (in 000s)	15.3	3.5	44.0	6,088	52.5	26.6	86.2	120
Fixed capital (in $ millions)	2,228.7	254.7	7,278.6	6,088	11,370.3	9,199.3	14,387.7	120
Sales (in $ millions)	3,295.1	585.8	10,437.9	6,088	12,642.3	7,136.4	19,208.2	120
R&D (in $ millions)	116.1	8.5	500.4	6,088	633.8	127.5	1,219.8	120
Pats (AvRZ)	23.5	2.0	102.1	6,088	71.1	3.0	217.5	120
Cites (AvRZ)	171.4	7.0	904.7	6,088	423.4	8.0	1,591.3	120
Pats (NBER 06)	36.9	3.0	157.3	6,088	214.1	11.5	486.7	120
Cites (NBER 06)	1,486.8	74.0	6,964.4	6,088	5,050.2	213.0	12,478.7	120
Pats (ADHPS)	37.0	3.0	155.5	6,088	195.8	15.5	442.8	120
Cites (ADHPS)	1,456.3	82.0	6,804.8	6,088	4,559.0	249.0	10,764.5	120
Pats (DISCERN)	38.4	5.0	130.9	5,012	n/a	n/a	n/a	n/a
Cites (DISCERN)	1,503.7	123.0	6,076.1	5,012	n/a	n/a	n/a	n/a

Panel A presents the list of non-U.S. firms in AvRZ's sample based on their latest country of headquarters. Panel B reports summary statistics for variables used by AvRZ for U.S. and non-U.S. firms based on their historical country of headquarters during AvRZ's sample period from 1991 to 1999.

Belenzon, and Sheer (2017) (DISCERN) data. These updated versions of the NBER data all include the GVKEY, so merging this data with the AvRZ data is relatively straightforward.[6,7,8,9] As can be seen in panel B, there is significant truncation in the AvRZ data, with the number of patent applications peaking in 1995. For example, the AvRZ data show that Pfizer (GVKEY: 8530) filed 85 patents in 1991, 113 in 1995, and 1 in 1999. In contrast, the NBER 06 data show that Pfizer filed 89 patents in 1991, 148 in 1995, and 238 in 1999. This truncation in the AvRZ data occurs as each patent is counted by its application year, and some may still

[6] NBER 06 data are matched to AvRZ's data using the files pat76_06_assg and dynass from the Patent Data Project (PDP) website (https://sites.google.com/site/patentdataproject/Home/downloads) and following the matching program provided by James Bessen (https://users.nber.org/~jbessen/matchdoc.pdf).

[7] ADHPS data are matched to AvRZ's data using the file cw_patent_compustat_adhps from David Dorn's website (https://www.ddorn.net/).

[8] DISCERN data are matched to AvRZ's data using the file DISCERN_Panel_Data_1980_2015 from the Duke Innovation & Scientific Enterprises Research Network (DISCERN, Version December 13, 2020) website (https://zenodo.org/records/4320782).

[9] We note that the number of matches with the DISCERN data is reduced because the DISCERN data are restricted to Compustat firms with (i) positive common shares traded in a given year (item: *cshtr_f*), (ii) positive R&D expense for at least one year during the period from 1980 to 2015 (item: *xrd*), and (iii) headquarters in the U.S. based on their latest headquarters location (item: *loc*).

Table 2
Truncation of patent data and institutional ownership.

Sample	All firms			U.S. firms		
Dependent Variable: Truncation of patent data	(1)	(2)	(3)	(4)	(5)	(6)
Share of institutions	−0.004***	−0.003**	−0.003***	−0.003**	−0.002*	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln (K/L)	0.014	0.009	0.034	0.007	0.008	0.046
	(0.038)	(0.035)	(0.059)	(0.035)	(0.034)	(0.059)
ln (Sales)	0.090***	0.075***	0.131***	0.071***	0.060***	0.132***
	(0.019)	(0.017)	(0.045)	(0.018)	(0.016)	(0.045)
ln (R&D stock)	0.068***	0.055***	0.269***	0.065***	0.053***	0.260***
	(0.013)	(0.010)	(0.069)	(0.012)	(0.010)	(0.068)
NAICS fixed effect	Yes	No	No	Yes	No	No
SIC fixed effect	No	Yes	No	No	Yes	No
Class fixed effect	Yes	Yes	No	Yes	Yes	No
Firm fixed effects	No	No	Yes	No	No	Yes
Adjusted R^2	0.489	0.416	0.697	0.504	0.431	0.691
Observations	6,208	6,208	6,208	6,088	6,088	6,088
Firms	803	803	803	784	784	784

This table presents estimates of OLS regressions of truncation of patent data on institutional ownership and the control variables used in AvRZ. Following Lerner and Seru (2022), the truncation of patent data is computed as the difference in the natural logarithm of one plus the number of granted patents dated by year of application in the 2006 NBER data and the natural logarithm of one plus the number of granted patents dated by year of application in the AvRZ data. Class fixed effects are based on the modal Hall, Jaffe, and Trajtenberg (2001) technology classes of granted patents dated by year of application in the AvRZ data. Technology class information for the AvRZ data is obtained using the file apat63_99 from the NBER website (https://www.nber.org/research/data/us-patents). NAICS fixed effects are six-digit NAICS industry dummies. SIC fixed effects are four-digit SIC industry dummies. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of time dummies.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

be pending during data collection. As discussed in Lerner and Seru (2022), this feature of the patent data can lead to misleading inferences because measurement issues from truncation are systematically related to firm characteristics, rather than being random.

Table 2 examines whether truncation biases are systematically related to institutional ownership. Following Lerner and Seru (2022), we estimate fixed effects ordinary least squares (OLS) regressions and present the results in six columns. The six columns include all firm-year observations from AvRZ's data (columns 1 to 3) and the reduced sample that excludes non-U.S. observations based on the historical headquarters of each firm (columns 4 to 6). The dependent variable is computed as the difference in the natural logarithm of one plus the number of granted patents dated by the year of application in the 2006 NBER data and the natural logarithm of one plus the number of granted patents dated by the year of application in the AvRZ data. While we select the NBER 06 data for illustration, we note that the results are similar when using other patent data instead.[10] The results are also similar when considering truncation of patent citations.[11] In specifications covering the six columns, we iteratively employ time, technology class, industry, and firm fixed effects to account for characteristics that might be driving the truncation bias (as in Lerner and Seru, 2022). We also explore how the truncation bias relates to AvRZ's control variables: firm size (*ln (Sales)*), capital-labor ratio (*ln (K/L)*), and the depreciated sum of past R&D expenditures (*ln (R&D stock)*).

Across all six columns of Table 2, the coefficient on institutional ownership is negative, and both economically and statistically significant. For example, the coefficient of 0.004 in column 1 implies that a 10 percentage points increase in institutional ownership is associated with a 12.2% decrease in the truncation of patent data for the average firm (the mean is 0.326). For comparison, AvRZ find that the same increase in institutional ownership is associated with a 5.5% increase in the number of patents for the average firm. If firms with higher institutional ownership exhibit less truncation bias, it raises the concern that the higher level of patenting reported in AvRZ might be an artifact of this truncation bias. Consistent with the results reported in Lerner and Seru (2022), we also find that larger firms, as well as those with higher R&D investment, exhibit greater truncation of patent data. Importantly, these relationships hold as well when non-U.S. firms are excluded from the sample. Moreover, these patterns persist under the most stringent specifications, including time and firm fixed effects.[12]

3. Replication of AvRZ

Building on the literature on patent production functions (Hausman, Hall, and Griliches, 1984), AvRZ adopt a Poisson panel regression of the following form:

$$E(INNOV_{i,t} \mid Z_{i,t}, \lambda_i, \delta_t) = exp(\beta INSTI_{i,t} + \gamma Z_{i,t} + \lambda_i + \delta_t) \quad (1)$$

[10] We select the NBER 06 data for illustration because the data would have been available to AvRZ when the paper was written.

[11] Citation information for the NBER 06, ADHPS, and DISCERN data is obtained using the file g_us_patent_citation from the PatentsView (Version September 20, 2023) website (https://patentsview.org/download/data-download-tables).

[12] Lerner and Seru (2022) rationalize their findings by suggesting that larger firms, and those investing more heavily in R&D, might produce more complex patents that require longer approval times. Lower institutional ownership could be related to greater truncation of patent data for similar reasons.

where $INNOV_{i,t}$ is a count-based measure of innovation (measured either by firm patent counts or firm patents weighted by forward citations) for firm i in period t, $INSTI_{i,t}$ represents the proportion of stock owned by institutions, and $Z_{i,t}$ denotes a vector of three controls, including sales, capital intensity, and the R&D stock. The term λ_i represents the firm fixed effect, introduced by either the pre-sample patent stock and a dummy for zero patents or the pre-sample stock of patents weighted by forward citations and a dummy for zero citations, while δ_t represents time dummy variables. AvRZ then estimate this model from 1991 to 1999.

3.1. Innovation and institutional ownership

Table 3 replicates AvRZ's main empirical finding, with the results reported in two panels. The two panels employ as dependent variables firm patents (panel A) and firm patents weighted by forward citations (panel B). The first column in each panel is an exact replication of AvRZ. The second column in each panel excludes non-U.S. firms from the sample based on their historical location of headquarters. The third column in each panel excludes firms with ADR listings from the sample. The fourth, fifth, and sixth columns in each panel use the NBER 06 patent data, the ADHPS patent data, and the DISCERN patent data, respectively, to address truncation issues.[13]

Two important findings emerge from the replication exercise in Table 3. First, when we exclude the 19 firms (or 120 firm-year observations) with historical headquarters located outside the U.S., or the 11 firms (or 68 firm-year observations) with ADR listings from the sample, we obtain a statistically insignificant coefficient on institutional ownership in both the patent and citations specifications. Similarly, the ownership coefficient becomes statistically insignificant in most specifications when we use any of the other patent data that are less prone to truncation issues during AvRZ's sample period. Importantly, in some of the specifications, the sign even flips. For example, we find a negative and statistically significant relationship between institutional ownership and citations when using the DISCERN patent data. The relationship is also negative and statistically significant when using the NBER 06 patent data and simultaneously excluding non-U.S. firms from the sample. Therefore, the positive relationship between institutional ownership and innovation is not robust.

Second, in most of the specifications, the economic magnitude of this relationship is small. For example, the point estimate on institutional ownership is very close to zero in both the patent and citation specifications when we exclude non-U.S. firms from the sample; the upper bound of the 95% confidence interval rules out the hypothesis that a 10 percentage point increase in institutional ownership is associated with an increase in patents (citations) of more than 4.0% (5.2%). The findings are very similar when we exclude firms with ADR listings from the sample. Similarly, the confidence interval rules out the hypothesis that a 10 percentage point increase in institutional ownership is associated with an increase in patents (citations) of more than 2.1% (0.6%) when we exclude non-U.S. firms from the sample and use the NBER 06 patent data. For comparison, AvRZ find that the same increase in institutional ownership is associated with an increase in patents (citations) of 5.5% (7.3%) for the average firm. Therefore, the confidence interval rules out the hypothesis that institutional ownership of an average firm is associated with the same increase in innovation as in AvRZ.

One concern with the estimates on institutional ownership is whether the test is adequately powered to detect a significant relationship between institutional ownership and innovation. If not, then the non-results could be due to limited statistical power (Abadie, 2020). To examine this possibility, we follow Bloom (1995) and compute the minimum detectable effect size (MDES) for each of the ownership estimates in Table 3.[14] The MDES measures the smallest effect that, if true, could be reliably detected given a certain significance level. The MDES of the ownership estimates suggests that the test is adequately powered to detect meaningful relationship between institutional ownership and innovation for the average firm. For example, in the case of patents, the MDES for ownership is 0.006 when we exclude non-U.S. firms from the sample. The number of patents in this sample has a mean of 23.5 and a standard deviation of 102.1. Therefore, the test could reliably detect an ownership effect on the order of 1/17,000 of one standard deviation. We conclude that our results are not due to poor statistical power.

Bettis, Gambardella, Helfat, and Mitchell (2014) argue that another concern with non-results is measurement error, which could affect both the ownership estimates and the standard errors. Anderson and Lee (1997), in their comparative study on the reliability of ownership data from various databases, conclude that the Compact D/SEC database is highly favorable compared to its peers. However, they identify some issues with the firms' outstanding shares reported in Compact D/SEC. To address these issues, we use the number of shares held by institutional owners from AvRZ and then divide it by the number of shares outstanding in CRSP.[15] Because the CRSP shares outstanding for ADRs are the shares outstanding of the ADR, and not the underlying issue, we note that this correction also increases the institutional ownership levels for non-U.S. firms to conventional levels.[16] Indeed, with this correction, non-U.S. firms show an average institutional ownership of 43.8 and a median of 37.8, compared to an average institutional ownership of 45.4 and a median of 47.5 for U.S. firms.

[13] We update AvRZ's initial pre-sample patent (citation) stock when using the NBER 06, ADHPS, and DISCERN patent data. We follow AvRZ for calculating the pre-sample patent (citation) stock. This is computed as the natural logarithm of $gPat(gCites)_t = Pat(Cites)_t + (1-\delta)gPat(gCites)_{t-1}$, where Pat(Cites) represents the firm's patents (citations) in year t, and δ is set at 0.30.

[14] We note that the MDES is the most commonly used measure in the recent finance literature to assess statistical test power (see, e.g., Coles, Heath, and Ringgenberg, 2022; Li and Ringgenberg, 2022; Denes, Howell, Mezzanotti, Wang, and Xu, 2023; Heath, Macciocchi, Michaely, and Ringgenberg, 2023).

[15] Based on the example of Baldor Electric Company (GVKEY: 1981) provided in the supplemental material of Anderson and Lee (1997), we note that the ownership data reported in AvRZ appears to be as of the second quarter for each year. We use CRSP shares outstanding as of the last monthly observation in that quarter for each year.

[16] See https://wrds-www.wharton.upenn.edu/documents/399/Data_Descriptions_Guide.pdf.

Table 3
Replication of AvRZ: Innovation and institutional ownership.

Panel A: Patent counts							
Test Dependent Variable: Pats	Exact Replication (1)	Exclude Non-U.S. Firms (2)	Exclude ADRs (3)	NBER 06 (4)	ADHPS (5)	DISCERN (6)	Exclude Non-U.S. Firms & NBER 06 (7)
Share of institutions	0.006***	−0.000	−0.000	0.002	0.003	−0.001	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ln (K/L)	0.325***	0.410***	0.407***	0.236*	0.310**	0.043	0.322**
	(0.105)	(0.107)	(0.107)	(0.124)	(0.122)	(0.098)	(0.135)
ln (Sales)	0.240***	0.274***	0.275***	0.302***	0.272***	0.277***	0.319***
	(0.054)	(0.052)	(0.052)	(0.067)	(0.069)	(0.059)	(0.063)
ln (R&D stock)	0.177***	0.147**	0.143**	0.309***	0.294***	0.408***	0.265***
	(0.066)	(0.063)	(0.063)	(0.090)	(0.086)	(0.074)	(0.086)
MDES	±0.006	±0.006	±0.006	±0.005	±0.005	±0.005	±0.005
Observations	6,208	6,088	6,140	6,208	6,208	5,012	6,088
Firms	803	784	792	803	803	652	784
Panel B: Citation counts							
Test Dependent Variable: Cites	Exact Replication (1)	Exclude Non-U.S. Firms (2)	Exclude ADRs (3)	NBER 06 (4)	ADHPS (5)	DISCERN (6)	Exclude Non-U.S. Firms & NBER 06 (7)
Share of institutions	0.007***	−0.000	0.000	0.003	0.004	−0.005*	−0.004*
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
ln (K/L)	0.440***	0.525***	0.524***	0.277*	0.371***	0.005	0.380**
	(0.132)	(0.133)	(0.134)	(0.148)	(0.139)	(0.200)	(0.150)
ln (Sales)	0.184***	0.236***	0.236***	0.204***	0.184***	0.242***	0.252***
	(0.063)	(0.063)	(0.063)	(0.070)	(0.070)	(0.088)	(0.067)
ln (R&D stock)	0.009	−0.026	−0.029	0.131	0.078	0.324**	0.075
	(0.107)	(0.099)	(0.099)	(0.142)	(0.120)	(0.157)	(0.127)
MDES	±0.007	±0.007	±0.007	±0.008	±0.008	±0.007	±0.007
Observations	6,208	6,088	6,140	6,208	6,208	5,012	6,088
Firms	803	784	792	803	803	652	784

This table presents estimates of Poisson regressions of innovation on institutional ownership, replicating AvRZ's main empirical finding. Panel A presents estimates where the dependent variable is the count of a firm's patents. Panel B presents estimates where the dependent variable is the count of a firm's patents weighted by the number of future citations. Column 1 in each panel is an exact replication of AvRZ (AVRZ's Table A4, column 3 or AVRZ's Table 1, column 5). Column 2 in each panel excludes non-U.S. firms from the sample based on their historical location of headquarters. Column 3 in each panel excludes firms with ADR listings from the sample. Column 4 in each panel uses the NBER 06 patent data instead of AvRZ's data. Column 5 in each panel uses the ADHPS patent data instead of AvRZ's data. Column 6 in each panel uses the DISCERN patent data instead of AvRZ's data. Column 7 in each panel excludes non-U.S. firms from the sample and uses the NBER 06 patent data instead of AvRZ's data. MDES is the minimum detectable effect size for the first coefficient reported in each column (Bloom, 1995). Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit SIC industry dummies, time dummies, and fixed effects using the Blundell, Griffith, and Van Reenen (1999) method.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

Table 4 shows the results when we replace AvRZ's institutional ownership measure with this corrected measure. We find that the positive relationship between institutional ownership and innovation does not exist across specifications when using the corrected measure, including those where we exclude non-U.S. firms from the sample, those where we exclude firms with ADR listings from the sample, and those where we use the updated patent data. In addition, this relationship does not even exist when we use the exact same specification as in AvRZ. We conclude that our results are not due to measurement error.[17]

3.2. Institutional ownership and product market competition

So far, our analysis suggests that the main empirical finding of AvRZ lacks robustness. We now replicate additional results from AvRZ that may interest readers. To save space, we focus on the combined adjustment of excluding non-U.S. firms from the sample

[17] We also experimented with Thomson Reuters (TR) institutional ownership data, combined with CRSP shares outstanding. These delivered results very similar to those presented with the Compact D/SEC. For example, replicating the exact specification from AvRZ, but using TR ownership data in combination with CRSP shares outstanding, leads to a coefficient (standard errors) on institutional ownership of −0.004 (0.002) in the patent specification and −0.003 (0.003) in the citation specification. When we repeat the specifications excluding non-U.S. firms from the sample, the coefficient (with standard errors) on institutional ownership is −0.002 (0.003) in both the patent and citation specifications.

Table 4
Replication of AvRZ: Innovation and institutional ownership with CRSP shares outstanding.

Panel A: Patent counts

Test Dependent Variable: Pats	Modified Replication (1)	Exclude Non-U.S. Firms (2)	Exclude ADRs (3)	NBER 06 (4)	ADHPS (5)	DISCERN (6)	Exclude Non-U.S. Firms & NBER 06 (7)
Share of institutions (Adj.)	−0.002	−0.001	−0.001	−0.002	−0.002	−0.001	−0.003*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
ln (K/L)	0.239*	0.407***	0.404***	0.207	0.276**	0.043	0.323**
	(0.127)	(0.106)	(0.106)	(0.130)	(0.130)	(0.098)	(0.134)
ln (Sales)	0.237***	0.273***	0.275***	0.304***	0.276***	0.276***	0.314***
	(0.054)	(0.050)	(0.051)	(0.065)	(0.066)	(0.059)	(0.062)
ln (R&D stock)	0.186***	0.147**	0.143**	0.309***	0.293***	0.408***	0.266***
	(0.066)	(0.062)	(0.061)	(0.089)	(0.083)	(0.074)	(0.085)
MDES	±0.005	±0.005	±0.005	±0.004	±0.004	±0.004	±0.005
Observations	6,208	6,088	6,140	6,208	6,208	5,012	6,088
Firms	803	784	792	803	803	652	784

Panel B: Citation counts

Test Dependent Variable: Cites	Modified Replication (1)	Exclude Non-U.S. Firms (2)	Exclude ADRs (3)	NBER 06 (4)	ADHPS (5)	DISCERN (6)	Exclude Non-U.S. Firms & NBER 06 (7)
Share of institutions (Adj.)	−0.003	−0.002	−0.002	−0.005***	−0.005***	−0.006**	−0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ln (K/L)	0.307**	0.515***	0.514***	0.231	0.318**	0.010	0.385***
	(0.156)	(0.129)	(0.129)	(0.157)	(0.151)	(0.198)	(0.146)
ln (Sales)	0.186***	0.237***	0.238***	0.213***	0.198***	0.229***	0.242***
	(0.065)	(0.059)	(0.059)	(0.065)	(0.064)	(0.084)	(0.063)
ln (R&D stock)	0.022	−0.024	−0.027	0.135	0.079	0.333**	0.087
	(0.104)	(0.093)	(0.093)	(0.132)	(0.112)	(0.153)	(0.122)
MDES	±0.006	±0.006	±0.006	±0.005	±0.005	±0.006	±0.006
Observations	6,208	6,088	6,140	6,208	6,208	5,012	6,088
Firms	803	784	792	803	803	652	784

This table presents estimates of Poisson regressions of innovation on institutional ownership, replicating AvRZ's main empirical finding with CRSP shares-outstanding data. Panel A presents estimates where the dependent variable is the count of a firm's patents. Panel B presents estimates where the dependent variable is the count of a firm's patents weighted by the number of future citations. Column 1 in each panel is a modified replication of AvRZ (AVRZ's Table A4, column 3 or AVRZ's Table 1, column 5). Column 2 in each panel excludes non-U.S. firms from the sample based on their historical location of headquarters. Column 3 in each panel excludes firms with ADR listings from the sample. Column 4 in each panel uses the NBER 06 patent data instead of AvRZ's data. Column 5 in each panel uses the ADHPS patent data instead of AvRZ's data. Column 6 in each panel uses the DISCERN patent data instead of AvRZ's data. Column 7 in each panel excludes non-U.S. firms from the sample and uses the NBER 06 patent data instead of AvRZ's data. MDES is the minimum detectable effect size for the first coefficient reported in each column (Bloom, 1995). Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit SIC industry dummies, time dummies, and fixed effects using the Blundell, Griffith, and Van Reenen (1999) method.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

and using the NBER 06 patent data. This addresses both the measurement error in institutional ownership for non-U.S. firms and the truncation bias in AvRZ's patenting series. We confirm that using other interventions (or their combinations) yields results qualitatively similar to those reported here. We also note that Table 1 in this paper provides the necessary details for readers to independently replicate AvRZ's findings when excluding non-U.S. firms from the sample, the most straightforward intervention in AvRZ's data and the sample AvRZ intended to focus on, without requiring any additional data.

AvRZ argue that their finding of a positive relationship between institutional ownership and innovation is consistent with the idea that institutional involvement in the innovation process alleviates managers' career concerns and risks, and increases tolerance for failure. This career concern interpretation suggests that the positive relationship between institutional ownership and innovation should be stronger when product market competition is higher. The alternative view, so AvRZ, is that institutional owners reduce managerial entrenchment by monitoring managers, who would otherwise enjoy a "quiet" life. Under this lazy manager interpretation, the positive relationship between institutional ownership and innovation should be stronger when competition in product markets is less intense. In particular, in highly competitive environments, where little managerial slack exists, there is less need for institutional monitoring.

Columns 1 to 4 in Table 5 replicate columns 1 to 4 of AvRZ's Table 2. Columns 5 to 8 follow the same specifications but exclude non-U.S. firms from the sample and use the NBER 06 patent data instead of AvRZ's data. Column 5 follows AvRZ's main specification, including product market competition. In line with AvRZ, competition shows a positive, albeit statistically insignificant, association with innovation. However, contrary to AvRZ, the coefficient on institutional ownership is negative and statistically significant.

Table 5
Replication of AvRZ: Institutional ownership and product market competition.

Test	Exact replication				Exclude non-U.S. firms & NBER 06			
Sample	All	All	High Comp.	Low Comp.	All	All	High Comp.	Low Comp.
Dependent Variable: Cites	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Share of institutions		0.082**				0.045		
× competition		(0.035)				(0.057)		
Share of institutions	0.007***	−0.064**	0.009***	0.002	−0.004*	−0.043	0.000	−0.007*
	(0.002)	(0.030)	(0.001)	(0.001)	(0.002)	(0.050)	(0.000)	(0.004)
Competition	0.343	−3.694	4.668**	1.376	0.287	−1.471	12.775***	−2.653
(1 − Lerner)	(2.329)	(3.330)	(2.310)	(4.947)	(3.422)	(3.815)	(2.670)	(4.358)
ln (K/L)	0.440***	0.452***	0.515***	0.331**	0.380**	0.385**	0.447***	0.298
	(0.142)	(0.141)	(0.112)	(0.156)	(0.152)	(0.156)	(0.113)	(0.208)
ln (Sales)	0.184**	0.189**	0.238***	0.129	0.252***	0.253***	0.293***	0.232***
	(0.077)	(0.075)	(0.070)	(0.080)	(0.056)	(0.055)	(0.052)	(0.065)
ln (R&D stock)	0.009	−0.001	−0.049	0.052	0.075	0.074	0.087	0.055
	(0.086)	(0.084)	(0.104)	(0.086)	(0.063)	(0.063)	(0.064)	(0.086)
MDES	±0.006	±0.097	±0.004	±0.004	±0.007	±0.157	±0.001	±0.011
Observations	6,208	6,208	3,085	3,123	6,088	6,088	3,037	3,051
Firms	803	803	542	637	784	784	531	620

This table presents estimates of Poisson regressions of innovation on the interaction between institutional ownership and product market competition, replicating AvRZ's Table 2. The dependent variable is the count of a firm's patents weighted by the number of future citations. Columns 1 to 4 are an exact replication of AvRZ (AVRZ's Table 2, columns 1 to 4). Columns 5 to 8 estimate the same specifications as columns 1 to 4 but exclude non-U.S. firms from the sample based on their historical location of headquarters and use the NBER 06 patent data instead of AvRZ's data. MDES is the minimum detectable effect size for the first coefficient reported in each column (Bloom, 1995). Robust standard errors are clustered at the three-digit SIC industry level (in parentheses). All regressions control for a full set of four-digit SIC industry dummies, time dummies, and fixed effects using the Blundell, Griffith, and Van Reenen (1999) method.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

Column 6 shows the interaction term between institutional ownership and competition, which is much smaller than that in AvRZ's specification and is statistically insignificant. Columns 7 and 8 split the sample into observations with high and low product market competition. In column 7, where competition is high, the coefficient on institutional ownership is very close to zero and statistically insignificant. In column 8, where competition is low, the coefficient on institutional ownership is large, negative, and statistically significant. These findings seem inconsistent with AvRZ's career concern interpretation (and also appear inconsistent with a lazy manager story).

3.3. Disaggregating ownership by type of institution

AvRZ's career concern interpretation is also based on the finding that quasi-indexed institutions have no association with innovation, while dedicated institutions demonstrate a large and positive relationship with it. AvRZ explained this finding by arguing that dedicated institutions are more incentivized to gather costly information about firm innovation and to monitor managers. Moreover, subsequent research often builds upon this particular finding. For example, He and Tian (2013) cited AvRZ, asserting that "dedicated institutional investors should enhance innovation to a significantly greater extent than non-dedicated institutional investors by providing a better shield to managers against short-term pressure" (p. 873). Similarly, Fang, Tian, and Tice (2014) cited AvRZ, stating that "an increase in the holdings of non-dedicated institutional investors may put increased pressure on managers to boost current profits and cut long-term investment in innovation or risk the exit of these investors" (p. 2088).

Columns 1 and 2 of Table 6 replicate columns 1 and 2 from AvRZ's Table 4. Columns 3 and 4 follow the same specifications but exclude non-U.S. firms from the sample and use NBER's 2006 patent data instead of the data from AvRZ. Importantly, in replicating AvRZ's specifications, we identify two deviations from what AvRZ described in their text: (i) R&D is not included as a control variable, and (ii) the number of employees is included as an additional control variable. Columns 5 and 6 address these deviations. Columns 7 and 8 also address these deviations but, as columns 3 and 4, exclude non-U.S. firms and use NBER's 2006 patent data. Column 7 shows that the coefficient on institutional ownership is also negative and statistically significant in the Bushee (1998) subsample, contrasting with AvRZ's findings. In column 8, we observe that the coefficient on quasi-indexed institutions is negative and statistically significant. Conversely, the coefficients on dedicated and transient institutions are much smaller than in the AvRZ specifications (and even reverse sign for dedicated institutions) and are statistically insignificant.[18]

[18] The negative and statistically significant coefficient on the quasi-indexed institutions might be surprising. However, in contrast to AvRZ's arguments in the paper, Appel, Gormley, and Keim (2016) and Schmidt and Fahlenbrach (2017) show that quasi-indexed funds do influence the governance and policies of firms. They argue that this is because these institutions are held to the most stringent fiduciary standards, and managers are inclined to consider their views due to higher turnover rates exhibited by these institutions. Bushee (2001) suggests that stringent fiduciary responsibilities can foster an excessive short-term focus in managers. Kim, Park, and Roy Song (2019) provide evidence that the higher turnover rates in a firm's institutional investor base are negatively related to the number of firm patents and citations.

Table 6
Replication of AvRZ: Disaggregating ownership by type of institution.

Sample: Bushee Test	Exact Replication		Exclude Non-U.S. firms & NBER 06		Corrected Replication		Exclude Non-U.S. firms & NBER 06	
Dependent Variable: Cites	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Share of institutions	0.006***		−0.009**		0.008***		−0.010***	
	(0.002)		(0.004)		(0.002)		(0.004)	
Share of dedicated		0.013**		−0.011		0.014**		−0.012
		(0.006)		(0.009)		(0.006)		(0.009)
Share of quasi-indexed		0.001		−0.020***		0.002		−0.022***
		(0.004)		(0.006)		(0.005)		(0.006)
Share of transient		0.017***		0.010		0.022***		0.011
		(0.007)		(0.008)		(0.007)		(0.008)
ln (K/L)	0.222*	0.198*	0.182	0.199	0.432***	0.401***	0.385***	0.390***
	(0.127)	(0.116)	(0.153)	(0.148)	(0.126)	(0.116)	(0.143)	(0.136)
ln (Sales)	0.663***	0.670***	0.649***	0.661***	0.146**	0.179***	0.236***	0.294***
	(0.120)	(0.115)	(0.143)	(0.138)	(0.061)	(0.061)	(0.061)	(0.066)
ln (R&D stock)					0.052	0.053	−0.012	−0.019
					(0.103)	(0.104)	(0.123)	(0.122)
ln (Emp)	−0.543***	−0.515***	−0.483***	−0.441***				
	(0.123)	(0.116)	(0.163)	(0.157)				
MDES	±0.006	±0.016	±0.010	±0.024	±0.007	±0.017	±0.010	±0.025
Observations	3,075	3,075	3,032	3,032	3,075	3,075	3,032	3,032
Firms	659	659	652	652	659	659	652	652

This table presents estimates of Poisson regressions of innovation on the type of institutional ownership, replicating AvRZ's Table 4. The dependent variable is the count of a firm's patents weighted by the number of future citations. Columns 1 and 2 are an exact replication of AvRZ (AVRZ's Table 4, columns 1 and 3). Columns 3 and 4 estimate the same specifications as columns 1 and 2 but exclude non-U.S. firms from the sample based on their historical location of headquarters and use the NBER 06 patent data instead of AvRZ's data. Columns 5 and 6 are a corrected replication of AvRZ. When implementing the specifications from columns 1 and 2, AvRZ deviate from the specifications described in the text and do not account for R&D inputs. The specifications also include the number of employees as an additional control variable, which appears nowhere else in the paper. Columns 7 and 8 estimate the same specifications as columns 5 and 6 but exclude non-U.S. firms from the sample based on their historical location of headquarters and use the NBER 06 patent data instead of AvRZ's data. MDES is the minimum detectable effect size for the first coefficient reported in each column (Bloom, 1995). Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit SIC industry dummies, time dummies, and fixed effects using the Blundell, Griffith, and Van Reenen (1999) method.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

3.4. Endogeneity of institutional ownership

To address selection issues, AvRZ consider an instrumental variable strategy using firms' additions to the S&P 500 Index. In an instrumental variable research design, a valid instrument must meet the relevance and exclusion conditions (Wooldridge, 2010). The first-stage F-statistic is informative about whether an instrument satisfies the relevance condition (see, e.g., Stock and Yogo, 2005; Andrews, Stock, and Sun, 2019; Lee, McCrary, Moreira, and Porter, 2022; Keane and Neal, 2023). For benchmarks, Stock and Yogo (2005) weak instrument tests show that a first-stage $F > 16.4$ (with a 95% confidence interval) is required so that a two-tailed 5% t-test rejects a true null hypothesis at a rate no higher than 10%. Lee, McCrary, Moreira, and Porter (2022) find that a much higher standard of $F > 104.7$ is required to ensure t-tests reject at a rate no higher than the correct 5% rate.[19] Keane and Neal (2023), and many others, show that if a first-stage F is in the 10 to 20 range, standard errors tend to be artificially small in samples where the estimate is most contaminated by the OLS bias. Therefore, if the OLS bias is positive, the t-test has little power to detect true negative effects, and inflated power to find positive effects.

Column 1 of Table 7 replicates the first-stage specification from column 5 of AvRZ's Table 5, including the F-statistic. We find that while the coefficient on the instrument S&P is positive and statistically significant, the F-statistic is 14.2, indicating that the S&P does not pass the pre-test for weak instruments when fixed effects are included (Stock and Yogo, 2005; Lee, McCrary, Moreira, and Porter, 2022). Column 3 follows the same specifications but excludes non-U.S. firms from the sample and uses NBER's 2006 patent data instead of the data from AvRZ. When doing so, the coefficient on the S&P 500 is much smaller than that in AvRZ's specification and is statistically insignificant, and the F-statistic decreases to 2.2. In replicating AvRZ's first-stage specification, we identify another important deviation from what AvRZ described in their text. In particular, instead of including the institutional ownership controls for fixed effects (which are available in AvRZ's data), AvRZ include the citation controls. Column 5 addresses this deviation. Column 6 also addresses this deviation but, in addition, excludes non-U.S. firms. In both specifications, we see that the coefficient on the S&P 500 is much smaller than that in AvRZ's specification, and the F-statistic is below 6.0. This suggests that the S&P 500 does not meet the relevance condition required for a valid instrument in AvRZ's setting.

[19] Regarding the rule-of-thumb threshold of $F > 10$, we note that Lee, McCrary, Moreira, and Porter (2022) demonstrate that the implementation and interpretation of the approach and results by Stock and Yogo (2005) have typically been incorrect by users.

Table 7
Replication of AvRZ: Controlling for endogeneity.

Test	Exact Replication		Exclude Non-U.S. firms & NBER 06		Corrected Replication		Exclude Non-U.S. firms & NBER 06	
Estimation Method	OLS (1st st.)	Poisson (Control Function)	OLS (1st st.)	Poisson (Control Function)	OLS (1st st.)	Poisson (Control Function)	OLS (1st st.)	Poisson (Control Function)
Dependent Variable	Share of Instit. (1)	Cites (2)	Share of Instit. (3)	Cites (4)	Share of Instit. (5)	Cites (6)	Share of Instit. (7)	Cites (8)
S&P 500	8.872***		2.829		3.420**		3.000**	
	(2.352)		(1.928)		(1.398)		(1.303)	
Share of institutions		0.029**		0.134**		0.014***		−0.010*
		(0.013)		(0.064)		(0.004)		(0.006)
ln (K/L)	−1.910*	0.482***	0.330	0.330**	−0.895	0.454***	−0.916	0.418***
	(1.112)	(0.119)	(1.028)	(0.130)	(0.791)	(0.116)	(0.736)	(0.133)
ln (Sales)	4.624***	0.053	5.943***	−0.582	2.446***	0.149***	2.352***	0.336***
	(0.598)	(0.099)	(0.511)	(0.415)	(0.462)	(0.056)	(0.378)	(0.097)
BGvR fixed effects?	Cites	Cites	Cites	Cites	Share of Instit.	Cites	Share of Instit.	Cites
F-statistics	14.227		2.153		5.985		5.303	
Adjusted R^2	0.371		0.410		0.613		0.621	
MDES	±6.520	±0.037	±5.344	±0.178	±3.875	±0.011	±3.611	±0.016
Observations	6,208	6,208	6,088	6,088	6,208	6,208	6,088	6,088
Firms	803	803	784	784	803	803	784	784

This table presents estimates of instrumental variable regressions, replicating AvRZ's Table 5. The instrumental variable is a dummy variable equal to one if the firm is a member of the S&P 500 Index. Columns 1 and 2 are an exact replication of AvRZ (AVRZ's Table 5, columns 5 and 6). Columns 3 and 4 estimate the same specifications as columns 1 and 2 but exclude non-U.S. firms from the sample based on their historical location of headquarters and use the NBER 06 patent data instead of AvRZ's data. Columns 5 and 6 are a corrected replication of AvRZ. When implementing the specification from column 1, AvRZ deviate from the fixed effects specification described in the text and use the pre-sample citation stock instead of the pre-sample institutional ownership. Columns 7 and 8 estimate the same specifications as columns 5 and 6 but exclude non-U.S. firms from the sample based on their historical location of headquarters and use the NBER 06 patent data instead of AvRZ's data. MDES is the minimum detectable effect size for the first coefficient reported in each column (Bloom, 1995). Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit SIC industry dummies and time dummies. BGvR fixed effects are the Blundell, Griffith, and Van Reenen (1999) pre-sample mean scaling estimator.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

The exclusion restriction requires the correlation between the error term and the instrument to be zero (Wooldridge, 2010). In the context of AvRZ, this restriction is met if the S&P 500 affects a firm's innovation solely through its influence on institutional ownership. The fulfillment of the exclusion restriction cannot be formally tested, as the error term is unobservable (Angrist and Pischke, 2009). While AvRZ provide several arguments supporting the likelihood that the exclusion restriction is satisfied in their setting, Reeb and Zhao (2022) contend otherwise. They argue that the S&P 500 also alters a firm's stock liquidity, which, according to Fang, Tian, and Tice (2014), is strongly related to innovation. In their replication of AvRZ's instrumental variable regressions, Reeb and Zhao (2022) discover that the effect of institutional ownership turns negative and becomes weakly significant when other channels (e.g., a reduction in the cost of capital) besides institutional ownership are considered (see also Lewellen and Lowry, 2021). In this case, we cannot draw causal inferences from the second-stage specifications presented in Table 7. Note, however, that we obtain results that are consistent with Reeb and Zhao (2022) when using the corrected data.

4. Discussion

Why is there no positive relationship between institutional ownership and innovation in U.S. firms? One potential explanation might be the lack of a substantial group of institutional investors in the U.S. who maintain long-term shareholdings. Indeed, Froot, Perold, and Stein (1992), Porter (1992), Bushee (2004), and Bolton and Samama (2013) argue that long-term institutions in the U.S., such as pension funds, do not exhibit the stable shareholding patterns seen in countries like Japan or Germany. They further emphasize that the effective investment horizon of U.S. institutional investors, as indicated by their share turnover frequency, is roughly one year—significantly shorter than that of individual investors.[20] As argued by Bolton, Scheinkman, and Xiong (2006), this horizon is far too short for institutional investors in the U.S. to be concerned with long-term firm performance or to understand

[20] In their survey of U.S. investor relations professionals, Beyer, Larcker, and Tayan (2014, p. 1) conclude that *"[t]he ideal shareholder base consists of long-term investors—still 'long-term' is not that long."* The authors find that, on average, companies view long-term investors as those who have an investment horizon of 2.8 years or more. Top management and corporate directors are seen as having the longest investment horizon among the different shareholder groups, with 93% and 92% of companies describing their investment horizon as long-term or somewhat long-term, respectively. Moreover, most companies agree or strongly agree that desirable shareholders are not activist investors (87%).

a firm's long-term activities, such as innovation. Bushee (2004) notes that for this reason, investor relations consultants recommend that U.S. firms target individual investors or foreign institutional investors.

In practice, about 87% of shares in U.S. firms are held by domestic institutional investors (Aggarwal, Erel, Ferreira, and Matos, 2011). To the extent that domestic institutional investors in the U.S. have influence on the design of executive compensation contracts, the model in Bolton, Scheinkman, and Xiong (2006) predicts a negative relationship between institutional investor turnover and long-term investments in innovation.[21] Consistent with this prediction, Bushee (1998) shows that managers in U.S. firms, where a large proportion of institutional investors have high portfolio turnover, tend to reduce R&D expenditures, particularly in firms where cuts in R&D can reverse earnings declines. Cremers, Pareek, and Sautner (2020) confirm these findings with more recent data, in a different setting, and with additional results for earnings and equity valuations, thereby testing additional predictions derived from Bolton, Scheinkman, and Xiong (2006).

Another potential reason for the lack of a positive relationship could be that domestic institutions may have closer relationships with the firms they invest in, and thus may be more accommodating to corporate insiders and less effective as monitors, as argued by Gillan and Starks (2003), Ferreira and Matos (2008), Aggarwal, Erel, Ferreira, and Matos (2011), Bena, Ferreira, Matos, and Pires (2017), and Luong, Moshirian, Nguyen, Tian, and Zhang (2017). Indeed, domestic institutions are often affiliated with banks that act as creditors, underwriters, advisors, or hold seats on boards (Ferreira and Matos, 2012). In contrast, because they are less encumbered by ties with corporate insiders, foreign institutions can reduce managerial entrenchment and promote investment in riskier opportunities for growth. Compared to their foreign counterparts, domestic institutions may also be less capable of tolerating the high-risk/high-return trade-off associated with innovation due to their limited ability to diversify risks within their more localized portfolios (Giannetti and Laeven, 2008). Moreover, given that domestic institutional investors are less involved in promoting cross-border mergers and acquisitions, these localized investments may impede knowledge spillovers and local firms' innovation (Ferreira, Massa, and Matos, 2009).

Consistent with these arguments, Davis and Kim (2007) report that Fidelity Investments takes an aggressive stance on governance issues in Europe, but is relatively acquiescent in the U.S., where it manages several corporate pension accounts. Aggarwal, Erel, Ferreira, and Matos (2011) show that foreign, but not domestic, institutional ownership increases the likelihood of the board having a majority of independent directors and a suitable number of directors, and makes it less likely that the firm adopts a staggered board provision. Ferreira and Matos (2008) find that firms with higher ownership by foreign institutional investors have higher firm valuations and better operating performance, unlike the absence of similar findings for domestic institutional investors. Bena, Ferreira, Matos, and Pires (2017) find that higher ownership by foreign institutions leads to an increase in capital and R&D expenditure, while no such relationship is observed for ownership by domestic institutions. Luong, Moshirian, Nguyen, Tian, and Zhang (2017) complement this evidence by showing a positive relationship between foreign institutional ownership and innovation outputs. Consistent with our results, the authors also find no evidence of a positive effect of domestic institutional investors.

5. Conclusions

AvRZ suggest that the rise in institutional ownership may have caused a substantial increase in innovation in the U.S. between 1991 and 1999. However, we identify multiple issues with their data. When these issues are addressed, their results become economically and statistically insignificant. In some instances, the corrected data even suggest a negative relationship between institutional ownership and U.S. innovation. We demonstrate that the results presented by AvRZ are influenced by their sample composition, the inclusion of non-U.S. firms, and truncation in their patenting series. We conclude that the often-cited finding that institutional ownership increases innovation in the U.S. is not robust. More attention to sample composition and methodological issues when using institutional ownership data and patent data is needed. Additionally, a more thorough reconciliation with previous findings would be beneficial.

CRediT authorship contribution statement

Markus Simeth: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **David Wehrheim:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[21] There are also other theories of short-termism that arrive at the same prediction but for different reasons. For example, Stein (1989) and von Thadden (1995) suggest that reductions in R&D arise because managers want to avoid a decline in earnings, which may lead to lower stock prices if investor trading is sensitive to earnings news.

Data availability

Data will be made available on request.

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