Web Appendix for "Innovation and Innovation Ownership" by Philippe Aghion, John Van Reenen and Luigi Zingales

A. Data Appendix

A.1. Main Dataset

We combine several firm level panel datasets. Because we are using patents (weighted by total future citations) as our key measure of innovation, we rely on the matching of the US Patents and Trademark Dataset (USPTO) with Compustat lodged at the NBER (see Hall et al, 2001, and Jaffe and Trajtenberg, 2002, for details). The matching was performed based on the ownership structure in 1989, so our sample is of a cohort of firms who were publicly listed in 1989 or entered subsequently. We follow these firms through the 1990s (including those who subsequently died). We use the updated version of the NBER match containing patent citations through to 2002 (downloaded from Bronwyn Hall's website, http://elsa.berkeley.edu/~bhhall/bhdata.html). All patents granted between 1963 and 1999 are included (just under 3 million patents) and citation information is available from 1975 to 2002 (over 16 million citations). The need to have some patent data is the main reason why our sample is much smaller than the full Compustat sample.

The second dataset we draw on is the text files from Compact Disclosure. This is an electronic version of the 13-F forms that all institutional organizations are obliged to lodge at the SEC on a quarterly basis if they have at least $100m in equity assets under discretionary management. The data includes the numbers of institutional owners, the number of share issues and the percentage of outstanding shares held by each institution (our key measure of institutional ownership). This dataset is not wholly consistent before 1990, so we use ownership data from 1991 onwards. The ownership data covers almost all the firms in the Computsat-USPTO match (we lose only three observations due to ownership changes in 1990), so the merging of the two datasets is straightforward. Compact Disclosure identifies five types of institutional owners: banks, insurance companies, investment companies, independent investment advisors and "other"

which includes internally managed pension funds, colleges and universities, foundations and other miscellaneous institutions and endowments (law firms, private investment partnerships, etc.).

The merged dataset consists of 1,078 firms and 7,923 observations between 1991 (the first year of the ownership data) and 1999 (the last year of the patent data). We are able to use lags of patent information back to 1969, however, so our patent stock variables include all this past information. Since our preferred regressions use fixed effects we condition our sample on firms who received at least citations and had at least two years of non-missing data on all variables between 1991 and 1999 over this period. This leaves us with 6,208 observations on 803 firms which is our baseline sample. The reason for the drop in sample is that many firms in the NBER USPTO/Compustat match patented prior to 1991 but not in the 1991-1999 period, and of those that did patent, many did not receive citations.

Tobin's Q is constructed following Hall et al (2005) which is the market value of the firm at the close of the year defined as the sum of common stock, preferred stock, the long-term debt adjusted for inflation and the short-term debt net of assets. The denominator of Q is capital, defined as the book value sum of net plant and equipment, inventories and investments in unconsolidated subsidiaries, intangibles[43] and others (all adjusted for inflation). Q was winsorized by setting it to 0.1 for values below 0.1 and at 20 for values above 20 following Lanjouw and Schankerman (2004).

Descriptive statistics are in Table A1.

A.2. Other datasets for robustness tests

In the robustness tests we also use other firm-level datasets. These datasets cover sub-samples of the firms in our database, so this is the reason why the number of observations in smaller in these regressions.

A.2.1. Entrenchment of managers

For information on governance we use the *Investor Responsibility Research Center* (IRRC) which publishes detailed listings of corporate governance provisions for individual firms in Corporate Takeover Defenses. The data on state takeover

[43]Note that these intangibles are normally the goodwill and excess market over book from acquisitions and do not include the R&D investment of the current firm, although they may include some value for the results of R&D by firms that have been acquired by the current firm.

legislation is from Pinnell (2000). Gompers et al (2003) construct an index of CEO power (relative to shareholders) as the sum of up to 24 unique provisions to do with how incumbent mangers can be protected. We split out the state law sub-index of Governance Index which is the simple average of the existence of six different laws.

A.2.2. CEO Firings Data

This data is from Fisman, Khurana and Rhodes-Kropf (2005). They followed a sample of largest firms in 1980 (the publicly traded Fortune 500 companies plus the 100 largest commercial banks, 100 largest financial services firms, 100 largest retail firms and 50 largest transportation firms) until 1995. The key variable they construct is whether the CEO was forcibly removed from his job, as opposed to another form of exit (e.g. if retired or ill). They do this by examining all CEO departures prior to the age of 61. They then use reports from the *Wall Street Journal* and *New York Times* to distinguish the type of exit. For information on managerial characteristics (such as CEO tenure) we use the S&P ExecuComp database. We are grateful to Ray Fisman for supplying us with this data. We measure profitability following Fisman et al (2005) by the ratio of operating profits divided by the sum of current assets and property, plant and equipment. Tenure is the number of years a CEO has held this position.

A.2.3. Disaggregation by type of Institutional Owner

It is possible to distinguish the name of the institutional owner from Compact Disclosure. Following Bushee (1998, 2001) we divide all institutions into three types: quasi-indexers, transient and dedicated. Bushee determined which firms fall into which category by using a factor analysis method where a larger group of institutional ownership characteristics are reduced to three: BLOCK (whether the institution tends to have large blockholdings or is very diversified), PTURN (whether the portfolio held is stable or turns over rapidly) and MOMENTUM (whether the institution reduces shareholding quickly in response to "bad news"). Using these three factors he creates three clusters of institutional ownership types. "Quasi-indexers" have low values of all three factors: they are diversified, have low turnover and are relatively insensitive to bad news. "Dedicated" investors have high blockholdings in single firms, low portfolio turnover and are insensitive to bad news. The final group of "transients" have low blockholdings in any one firm, high turnover and high momentum. Brian Bushee kindly supplied us with

the data breaking institutional owners into these three classes for more recent data that we could match in to our sample.

Using this categorization we can calculate for each year, what proportion of a firm's shares are held by each of these institutional investors. To ensure that the data is consistent with use only observations where our measure of institutional ownership and Bushee's where within 5% of each other (the correlation between the two measures is over 0.99).

B. Econometric Details

Under exogeneity of $INSTIT_{it}$ we have the moment condition:

$$E(\upsilon_{it}|INSTIT_{it}, \mathbf{x}_{it}, \eta_i, \tau_t) = 1$$

where υ_{it} is the error term associated with the sample analog of (0.1). This will not hold under endogeneity of $INSTIT_{it}$.We assume that the instrument z_{it} (membership of the S&P500) obeys the reduced form:

$$INSTIT_{it} = \pi z_{it} + \boldsymbol{\beta}^o \mathbf{x}_{it} + \eta_i^o + \tau_t^o + \upsilon_{it}^o$$

with

$$E(\upsilon_{it}^o|z_{it}, x_{it}, \eta_i^o, \tau_t^o) = 1$$

so that controlling for υ_{it}^o in the conditional moment condition is sufficient to remove the endogeneity bias. In estimation we use the extended moment condition:

$$E(CITES_{it}|\mathbf{x}_{it}, \eta_i, \tau_t, \upsilon_{it}^o) = \exp(\alpha INSTIT_{it} + \boldsymbol{\beta}\mathbf{x}_{it} + \eta_i + \tau_t + \rho(\upsilon_{it}^o)) \quad \text{(B.1)}$$

where $\rho(\upsilon_{it}^o)$ is a non-parametric function of υ_{it}^o (empirically we used a polynomial series expansion). A simple test for exogeneity is the joint significance of the residuals in equation (B.1).

C. Theoretical Appendix

In the four remarks below we discuss how our main theoretical predictions are affected if we modify our above assumptions, namely: (i) that the manager finds out more about the manager's ability if the manager innovates; (ii) that it costs $\delta > 0$ for a manager to relocate to another sector; (iii) that managerial ability

is not perfectly correlated across sectors; (iv) that competition does not affect a non-innovating manager.

Remark 1: Consider what happens if the institutional investor finds out about the manager's ability irrespective of whether the manager innovated. In this case we have:

$$U(i = 0 : monitor) = \frac{1}{2}\overline{\theta} + \frac{1}{2}\underline{w} = U(i = 1 : monitor).$$

But then the manager is deterred from innovating altogether, since

$$U(i = 1 : monitor) - U(i = 0 : monitor) = 0 < I.$$

This is clearly an extreme outcome due to the fact that innovation has no benefits for the manager, but only a cost. In general, it is reasonable to assume that innovation can benefit the manager and that an investor who spends resources to understand the process can acquire a better perspective about the quality of the innovative effort made, regardless of the outcome.

Remark 2: One borderline case to our model, is when managers can relocate costlessly to other sectors (for example because basic skills are general). In this case $\delta = 0$ which does not violate the above assumptions, in particular Assumption 4. Thus our above conclusions carry over to that case.

Remark 3: Suppose that, unlike what we have assumed so far, managerial ability is the same in all sectors. In particular, a manager who is found out to be bad in one job, is never hired by other sectors. Thus $\underline{w} = 0$ and therefore in the absence of an institutional investor the ex ante utility of a manager who innovates is equal to

$$U(i = 1) = \frac{1}{2}p\overline{\theta},$$

whereas in the presence of an institutional investor who monitors the ex ante utility conditional upon innovating is equal to

$$U(i = 1 : monitor) = \frac{1}{2}\overline{\theta} = U(i = 0).$$

Hence, in this case, even though it increases the expected utility of a manager who decides to innovate, monitoring by the institutional investor does not suffice to induce the manager to innovate.

Remark 4: Consider the following variant of our model where competition also affects non-innovating managers, e.g. because it forces them to relocate to another sector. More precisely, the manager must relocate whenever the firm is

imitated, which in turn we assume to happen with probability 2π in the absence of innovation. We then have:

$$U(i=0) = (1-2\pi)\frac{1}{2}\overline{\theta} + 2\pi\underline{w}.$$

In this case, an increase in competition π increases the net gain $(U(i=1) - U(i=0) - I)$ of an innovating manager in the absence of institutional investor. But it increases by even more the net gain $(U(i=1:monitor) - U(i=0) - I)$ of an innovating manager monitored by an institutional investor. Thus the introduction of an institutional investor magnifies the escape competition effect of innovation, which in turn reinforces the complementarity between institutional investment and competition.

NOT FOR PUBLICATION: APPENDIX FIGURES AND TABLES

TABLE A1: DESCRIPTIVE STATISTICS

VARIABLE	Mean	Standard deviation	Median	Min	Max	Source	Observations
(Future) Cite-weighted patent counts	176	923	7	0	23,121	USPTO	6,208
Patents	24	105	2	0	2,405	USPTO	6,208
% Institutional Ownership	45.5	23.1	48.2	0	100	SEC	6,208
Employment (1000s)	16.0	45.4	3.7	0.05	756.3	Compustat	6,208
Sales ($m)	3,475	10,750	608	0.019	174,694	Compustat	6,208
R&D ($m)	126	528	9.0	0	8900	Compustat	6,208
1-Lerner Index	0.861	0.044	0.871	0.488	0.974	Compustat	6,208
Index of State Laws blocking hostile takeovers	31.0	22.9	16.7	0	100	IRRC and Gompers et al (2003)	1,139
Governance Index	9.7	2.9	10	2	18	IRRC and Gompers et al (2003)	1,357
CEO Firing	0.04	0.20	0	0	1	Fisman et al (2005)	1,897
CEO exit (not firing)	0.09	0.018	0	0	1	Fisman et al (2005)	1,897
CEO Tenure	7.6	6.7	6	0	47	Fisman et al (2005)	1,897
Profits/Assets	0.094	0.052	0.087	-0.064	0.577	Compustat	1,897

NOTES: Data is taken from the sample of 6,208 observations (803 firms) used for the regression of citations/patents sample unless otherwise stated.

TABLE A2: PRODUCTIVITY AND INSTITUTIONAL OWNERSHIP

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Ln(Sales)	Ln(Sales)	Ln(Sales)	Ln(Sales)	Ln(Sales)	Ln(Sales)
Sample	All	All	All	All	High Comp	Low Comp
Share of institutions	0.0035***	0.0032***	0.0031***	0.0008*	0.0016**	-0.0003
	(0.0007)	(0.0006)	(0.0006)	(0.0004)	(0.0006)	(0.0007)
Ln(Labor)	1.0257***	0.6371***	0.6360***	0.5044***	0.5495***	0.4172***
	(0.0144)	(0.0425)	(0.0420)	(0.0451)	(0.0839)	(0.0878)
Ln(Capital)		0.3721***	0.3502***	0.3263***	0.3228***	0.3320***
		(0.0374)	(0.0382)	(0.0387)	(0.0539)	(0.0404)
Ln(R&D stock)			0.0279***	0.0399*	0.0037	0.0790**
			(0.0100)	(0.0232)	(0.0303)	(0.0386)
Fixed Effects	No	No	No	Yes	Yes	Yes
Observations	6,208	6,208	6,208	6,208	3,085	3,123

NOTES: *** = significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level. Coefficients estimated by OLS with standard errors clustered by firm (in parentheses).Controls for four digit industry dummies and time dummies included in all columns. Column (5) and (6) also include the time-varying Lerner index. Estimation period is 1991-1999 over 803 firms. "High (Low) Comp" is the sub-sample where the industry (1-Lerner) is above (below) the sample median (0.871) as in Table 2. Standard errors clustered ay the firm level in columns (1)-(4) and at the three digit industry level in columns (5) and (6).

TABLE A3: ROBUSTNESS TESTS OF BASIC RELATIONSHIP BETWEEN INNOVATION AND INSTITUTIONAL OWNERSHIP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Years	**CITES 1991-1999**	**CITES 1991-1999**	**CITES 1991-1999**	**CITES 1991-1999**	**CITES 1991-1994**	**CITES 1995-1999**	**CITES 1991-1999**	**CITES 1991-1999**	**CITES 1991-1999**	**CITES 1991-1999**
	All	**All**	**High Comp**	**Low Comp**	**All**	**All**	**All**	**High Comp**	**Low Comp**	**All**
Share of institutions	0.007***				0.007***	0.008***	0.007***	0.009***	0.003	0.006***
	(0.002)				(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)
Shareholder concentration	0.004	0.005**	0.007***	0.004**						
	(0.003)	(0.003)	(0.002)	(0.001)						
ln(CITES)$_{t-1}$										
Ln(R&D flow)$_{t}$							0.284**	0.226	0.285***	0.494***
							(0.128)	(0.192)	(0.094)	(0.097)
Ln(R&D flow)$_{t-1}$										0.195***
										(0.072)
Ln(R&D flow)$_{t-2}$										0.053
										(0.085)
Observations	6,208	6,208	3,085	3,123	2,922	3,286	6,208	3,085	3,123	5,982
Firms	803	803	543	637	786	739	803	543	637	790

NOTES: ***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level. All columns estimated by Poisson regression. CITES, is a count of a firm's patents weighted by the number of future citations, COUNT is the raw count of patents. Coefficients are from count data models with standard errors clustered by firm (in parentheses). All regressions control for ln(sales), ln(capital/sales) ratio), and a full set of four digit industry dummies and time dummies) and fixed effects controls using the Blundell, Griffith and Van Reenen (1999) pre-sample mean scaling estimator). Columns (1)-(6) also control for ln(R&D stock). Columns (3), (4), (8) and (9) also control for time-varying Lerner index. Shareholder concentration is the proportion of equity owned by top five shareholders Column (10) includes lags of ln(R&D) expenditure up to t-6, although only the results through t-2 are shown for brevity. "High (Low) Comp" is the sub-sample where the industry (1-Lerner) is above (below) the sample median (0.871) as in Table 2. Standard errors are clustered at the firm level in columns (1), (2),(5)-(7) and (10) and at the three digit industry level in other columns.

TABLE A4: USING PATENT COUNTS INSTEAD OF CITE-WEIGHTED COUNTS AS THE DEPEDENT VARIABLE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Method	**Poisson**	**Poisson**	**Poisson**	**Poisson**	**Poisson**	**Negative Binomial**	**Negative Binomial**	**Negative Binomial**
Sample	**All**	**All**	**All**	**High Competition**	**Low Competition**	**All**	**All**	**All**
Dependent Variable	**PATENTS**	**PATENTS**	**PATENTS**	**PATENTS**	**PATENTS**	**PATENTS**	**PATENTS**	**PATENTS**
Share of institutions	0.006***	0.006***	0.006***	0.008***	0.002	0.005***	0.005***	0.003*
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Ln(K/L)	0.388***	0.272**	0.325***	0.359***	0.323**	0.540***	0.324***	0.277***
	(0.124)	(0.130)	(0.105)	(0.102)	(0.145)	(0.085)	(0.075)	(0.065)
Ln(Sales)	0.875***	0.405***	0.240***	0.300***	0.177	0.645***	0.351***	0.163***
	(0.036)	(0.082)	(0.054)	(0.067)	(0.124)	(0.053)	(0.065)	(0.043)
Ln(R&D stock)		0.481***	0.177***	0.105*	0.242*		0.382***	0.183***
		(0.089)	(0.066)	(0.057)	(0.147)		(0.049)	(0.030)
Fixed Effects	No	No	Yes	Yes	Yes	No	No	Yes
Observations	6,208	6,208	6,208	3,085	3,123	6208	6,208	6,208

NOTES: ***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level. 803 firms in full sample. PATENTS is a count of a firm's patents. Coefficients above standard errors clustered by firm in all columns except (4) and (5) where they are clustered by three digit industry (in parentheses). All regressions control for a full set of four digit industry dummies and time dummies. Columns (4) and (5) also control for the industry Lerner index. Estimation period is 1991-1999; fixed effects controls using the Blundell, Griffith and Van Reenen (1999) pre-sample mean scaling estimator. "High (Low) Comp" is the sub-sample where the industry (1-Lerner) is above (below) the sample median (0.871) as in Table 2.

TABLE A5: ALLOWING THE INSTITUTIONAL OWNERSHIP EFFECT TO VARY WITH MANAGERIAL "ENTRENCHMENT"

CITES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Measure of Entrenchment		**State Laws against hostile takeovers**				**Governance Index of managerial power over shareholders**		
Entrenchment	POOLED	POOLED	LOW (FEW STATE LAWS BLOCK TAKEOVERS)	HIGH (MANY LAWS BLOCK TAKEOVERS)	POOLED	POOLED	LOW	HIGH
(Share of institutions) * (State Laws blocking hostile takeovers)		-0.0004** (0.002)						
(Share of institutions) * (Gompers' Index)						-0.0026** (0.0010)		
Share of institutions	0.0071**	0.0174***	0.0104***	0.0038	0.0080***	0.0321***	0.0090***	0.0083**
	(0.0030)	(0.0052)	(0.0032)	(0.0048)	(0.0028)	(0.0098)	(0.0033)	(0.0039)
State Laws blocking hostile takeovers	-0.0035	0.0206**	-0.0222**	0.0002				
	(0.0043)	(0.0083)	(0.0109)	(0.0075)				
Gompers' Index					-0.0501*	0.1054*	0.0128	-0.1053
					(0.0258)	(0.0611)	(0.0434)	(0.0655)
Observations	1,139	1,139	675	464	1,357	1,357	613	744

NOTES: ***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level. The dependent variable is future cite-weighted patent regressions. Each column is a separate Poisson regression as in Table 1 column (5): all regressions control for year dummies, ln(sales), ln(capital/labor), ln(R&D stock), industry dummies (three digit) and fixed effects using Blundell et al (1999) method. Standard errors are clustered at the firm-level. State Takeover law index is an average of 6 different state laws that make it harder to launch a hostile takeover bid. Governance Index is an average of up to 26 provisions in the firm's charter. The entrenchment measures are based on data from IRRC in 1993, 1995 and 1998. 406 firms in columns (1)-(4) and 539 firms in columns (5)-(8). In columns (3) and (4) low (high) entrenchment is when the state law index is under (over) 16.7. In columns (7) and (8) Low (High) entrenchment is when the Governance Index is less (greater) than 10.