Internet Appendix for "The Bright Side of Financial Derivatives: Options Trading and Firm Innovation" by Iván Blanco and David Wehrheim

This Internet Appendix provides additional material to the results presented in *"The Bright Side of Financial Derivatives: Options Trading and Firm Innovation."* In Section A.1, we describe the construction of the main data set. In Section A.2, we discuss and report robustness checks for the baseline results reported in Section 4 of the paper. In Section A.3, we report additional tests that supplement other parts of the main article. Descriptive statistics are in Table A16.

A.1. Main data set

The main firm-level data sample is generated through the combination of several data sets. Because we are using patents (weighted by total future citations) as our key measure of innovation, we rely on the matching of the United States Patent and Trademark Office (USPTO) to the North American Compustat data hosted at the National Bureau of Economic Research (NBER) (see Hall, Jaffe, and Trajtenberg, 2001; Jaffe and Trajtenberg, 2002, for details). The main matching was performed based on the concordance file provided by Bessen (2009) that connects the assignee identification number of the NBER patent data set to the Compustat GVKEY identification number. These connections reflected the firms and subsidiaries identified in the Who Owns Whom? database (published annually by Dun & Bradstreet International). Ownership may change through mergers, acquisitions, or spin-offs, and when an organization is acquired/merged/spun-off, its patents likely transfer to the new owner. These changes have been tracked using data on the mergers and acquisitions of public companies reported in the SDC database. We use the updated version of the NBER match containing citations through 2006 (downloaded from the NBER Patent Data Project website, https://sites.google.com/site/patentdataproject). All patents granted between 1976 and 2004 are included (just under three million patents), and citation information is available from 1976 to 2006 (over 23 million citations). The need to have some patent data is the main reason that our sample is considerably smaller than the full Compustat sample.

The second data set we draw on comes from OptionMetrics LLC, a financial research firm specializing in the analysis of option markets. The IvyDB U.S. data set from OptionMetrics contains daily closing option prices (bid and ask) for all U.S. exchange-listed and Nasdaq equities and market indexes, as well as all U.S.-listed index and equity options, starting from January 1996 (which is why this is the first year in our sample). In addition to option prices, it also contains daily time-series of the underlying spot prices, dividend payments and projections, stock splits, historical daily interest rate curves and, most important, option volumes. Implied volatilities and sensitivities (delta, gamma, vega, and theta) for each option are also calculated. The comprehensive nature of the database makes it most suitable for empirical work on option markets. The primary key (Security ID) for all data contained in IvyDB is linked to the security's CUSIP number and ticker symbol, and hence merging the two data sets is straightforward.

Third, we obtain data on institutional ownership from Thomson Reuters' CDA/Spectrum Institutional Holdings data set. Starting in 1978, all institutions with more than $100 million in securities under discretionary management have been required to report their holdings to the Securities and Exchange Commission (SEC) using Form 13F. Each quarter, these institutions must disclose any common stock positions greater than 10,000 shares or greater than $200,000 in value. The data include the number of institutional owners, the number of share issues, and the percentage of outstanding shares held by each institution. For each fiscal year, we take the average of the four quarterly institutional holdings given by Form 13F and treat that as our measure of institutional ownership (*InstOwn*). As the ownership data do not cover all the firms in the data set, we lose 304 firms when we match the Compustat accounting data and ownership data.

We began with the NBER USPTO/Compustat match and kept all domestic firms trading on NYSE (stock exchange code 11), Amex (12) and Nasdaq (14) with non-missing accounting data on fixed assets (PPENT), employees (EMP), and sales (SALE) that are listed on Compustat for at least three years. As our preferred regressions use fixed effects, we condition our sample on firms that had received at least one citation and had at least two years of non-missing data on all variables. This leaves us with a merged data set of 1,329 firms and 9,265 observations between 1996 (the first year of the options data) and 2004 (the last year of the patent data). For reasons explained in the main article, our final sample consists of firms with positive options volume that are active in five broadly defined R&D-intensive industries: (i) pharmaceuticals (SIC code 283), (ii) industrial and commercial machinery and computer equipment (35), (iii) electronics and communications (36), (iv) transportation equipment (37), and (v) instruments and related products (38). This leaves us with 3,271 observations on 548 firms, which is our baseline sample.

A.2. Robustness tests for the baseline results

We conduct a rich set of robustness checks of our baseline results and report them in Tables A1 – A11. First, we check whether our results are robust to alternative econometric models. We begin with a Poisson model where the dependent variable is the number of cite-weighted patents and the number of (unweighed) patents and report the results in Table A1. The coefficients on *Ln(Optvol)* remain positive and significant across all columns, consistent with our baseline findings. For example, the coefficient estimate on *Ln(Optvol)* is 0.143 (p-value < 0.01) if we reproduce our baseline fixed effects model of cite-weighted patents (column 4 of Table 2 in the main article) and is 0.106 (p-value < 0.05) when we use simple patent counts as the dependent variable. Next, because our dependent variables are right-skewed (e.g., 24% of our firm-year observations have zero citations), we use three modeling strategies that take this into account. We report the results in Table A2. In columns 1 and 2, we adopt a quantile regression approach at the 75^{th} percentile. The baseline results continue to hold, and we obtain similar findings if we run the quantile regressions at the 70^{th}, 80^{th}, 85^{th}, and the 95^{th} percentiles. We then use zero-inflated negative binomial (columns 3 and 4) and zero-inflated Poisson models (columns 5 and 6). We also find consistent results.

Second, because our main analysis uses contemporaneous independent variables, we run alternative specifications where we lag the variables. As a first step, our approach was to

empirically explore the effects of time lags between options trading and the dependent variables. Estimating models with various time lags (i.e., from $t-1$ to $t-5$) for the options trading variable, we found broadly consistent results for all models, but with coefficients on *Ln(Optvol)* that were consistently larger than those obtained from the contemporaneous models. We present the results of models with one- and three-year lagged explanatory variables, as adding further lags reduces the number of observations for firms in the data set, without providing any appreciable gain in the precision of the estimates. The coefficients on *Ln(Optvol)* are shown in Panels A (one-year lag) and B (three-year lag) of Table A3, and are positive in all regressions. For example, the coefficients in column 1 suggest that increasing options trading activity from the sample median ($8.5 million) to the 75$^{\text{th}}$ percentile ($53.5 million) is associated with a 98% increase in future cite-weighted patents in the following year and a 67% increase in three years, all significant at the 1% level.

Third, we examine whether the effect of options volume on innovation is monotonic (i.e., after conditioning on covariates). In Table A4, we begin with the inclusion of *Ln(Optvol)* and its squared term. We find that the impact of *Ln(Optvol)* on cite-weighted patents remains positive and significant (coefficient = 0.105 and p-value < 0.1 in column 1 of Table A4), but the coefficient estimate on the squared term, *Ln(Optvol) x Ln(Optvol)*, is not significant. Next, we create a dummy variable, *High Optvol*, that equals one if the options volume for a given firm is above the median in that year and zero otherwise and interact this dummy with *Ln(Optvol)*. We then re-estimate Eq. (1) in the main article by adding the *High Optvol* dummy and the interaction term, *Ln(Optvol) x High Optvol*. However, as shown in columns 2, 4, and 6, the coefficient estimates on the interaction terms are not statistically significant, while the coefficients on *Ln(Optvol)* remain positive and highly significant. In untabulated analyses, we obtain similar results if we replace the dependent variable with unweighted patent counts. Overall, and consistent with the bivariate relationship in Fig. 1 in the main article, it appears that the effect of options trading activity on innovation is monotonic.

Fourth, our preferred control for R&D inputs is a continuous measure of the depreciated sum of past R&D expenditures. Although widely used in prior studies, it may partly conceal some of the effects of R&D. To mitigate such concerns, we include only the contemporaneous R&D flow and establish dummy variables based on deciles of the distribution of *R&D stock*. We report the results in Tables A5 and A6, respectively. In both cases, the coefficients on options volume continue to be positive and significant. For example, according to columns 1 and 2 of Table A5, an increase in options volume from the sample median ($8.5 million) to the 75$^{\text{th}}$ percentile ($53.5 million) is associated with a 74% increase in citations and a 74% increase in the number of patents filed.

Fifth, as our sample period (1996 – 2004) includes the "dot-com bubble," which is conventionally dated between 1996 and 2000, we rerun our regressions for the two subperiods 1996 – 2000 and 2001 – 2004. As Table A7 shows, the coefficients on *Ln(Optvol)* are positive and significant (at the 1% level) in both subperiods, which provides reassurance that our results are not driven by high coefficient magnitudes in the earlier or later periods.

Finally, in Table A8, we report the regression results after the inclusion of additional (financial) control variables. In Table A9, we report the regression results after controlling for

firms' external knowledge acquisition activities. In Table A10, we report the regression results on the differential effect of options trading on innovation in R&D- and non-R&D-intensive industries based on a matched sample. In Table A11, we report the within-firm regression results that compare changes in innovation before and after firms' inclusion in options markets. These findings are discussed in Section 4.2 of the main article.

A.3. Other tests

In this section, we present additional regression results that supplement other parts of the paper. We discuss these results in the main text.

In Table A12, we report the results from the two-stage least-squares regression (2SLS) using the average open interest across all options on a stock throughout the calendar year as an alternative instrument.

In Table A13, we present the regression results on the interaction between options volume and managerial entrenchment using the "Entrenchment Index" (E-Index) (see Bebchuk, Cohen, and Ferrell, 2009, for details).

In Table A14, we report the regression results from examining the effect of firm innovation (and options volume) on a firm's market valuation (Tobin's Q).

In Table A15, we present the regression results from examining the effect of options volume on innovation after controlling for all five economic mechanisms.

References

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Table A1
Options volume and innovation–Poisson model.

This table presents estimates of Poisson panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) on options volume (*Optvol*) and other firm-level control variables. Firms in all columns: 548. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies and time dummies. The time period is 1996 – 2004 (with citations up to 2006); fixed effects are based on including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Dependent var.	CITES				PATS			
Method: Poisson	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(Optvol)	0.230***	0.139***	0.238***	0.143***	0.132***	0.117***	0.122**	0.106**
	(0.062)	(0.034)	(0.067)	(0.035)	(0.051)	(0.042)	(0.053)	(0.044)
InstOwn	-0.040	-0.088	-0.055	-0.102	-0.189	-0.083	-0.090	-0.054
	(0.240)	(0.221)	(0.219)	(0.215)	(0.237)	(0.235)	(0.223)	(0.222)
Ln(K/L)	0.634***	0.519***	0.676***	0.555***	0.477**	0.371**	0.530***	0.427***
	(0.232)	(0.164)	(0.252)	(0.170)	(0.186)	(0.165)	(0.195)	(0.165)
Ln(Sales)	0.531***	0.250***	0.219*	0.128*	0.610***	0.330***	0.214**	0.148**
	(0.091)	(0.067)	(0.117)	(0.076)	(0.070)	(0.065)	(0.095)	(0.069)
Ln(Age)	-0.042	-0.261**	-0.175*	-0.330***	-0.014	-0.255**	-0.191**	-0.352***
	(0.110)	(0.112)	(0.102)	(0.099)	(0.086)	(0.109)	(0.086)	(0.093)
Ln(R&D stock)			0.349**	0.165*			0.469***	0.275***
			(0.138)	(0.090)			(0.109)	(0.091)
Firm fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Observations	3,271	3,271	3,271	3,271	3,271	3,271	3,271	3,271

Table A2
Options volume and innovation–Other (alternative) specifications.

This table presents estimates of quantile (at the 75th percentile), zero-inflated NB, and zero-inflated Poisson panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) on options volume (*Optvol*) and other firm-level control variables. Firms in all columns: 548. Robust standard errors in columns 1 and 2 are obtained from 200 bootstrap replications. All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Method	Quantile regression		Zero-inflated NB		Zero-inflated Poisson	
Dependent var.	Ln(1+CITES)	Ln(1+PATS)	CITES	PATS	CITES	PATS
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Optvol)	0.105***	0.106***	0.164***	0.142***	0.155***	0.115**
	(0.016)	(0.013)	(0.028)	(0.024)	(0.040)	(0.049)
InstOwn	-0.034	-0.153*	0.046	0.102	-0.088	0.004
	(0.128)	(0.088)	(0.164)	(0.175)	(0.211)	(0.218)
Ln(K/L)	0.021	0.032	0.167**	0.182***	0.564***	0.449***
	(0.052)	(0.036)	(0.070)	(0.060)	(0.168)	(0.163)
Ln(Sales)	0.123***	0.118***	0.108***	0.138***	0.114	0.137**
	(0.025)	(0.021)	(0.038)	(0.043)	(0.074)	(0.068)
Ln(Age)	-0.167***	-0.082*	-0.215**	-0.235***	-0.318***	-0.356***
	(0.060)	(0.044)	(0.087)	(0.076)	(0.097)	(0.092)
Ln(R&D stock)	0.315***	0.262***	0.285***	0.266***	0.163*	0.276***
	(0.030)	(0.025)	(0.039)	(0.044)	(0.088)	(0.089)
Observations	3,271	3,271	3,271	3,271	3,271	3,271

Table A3
Options volume and innovation–Lagged explanatory variables.

This table presents estimates of OLS, NB, and Poisson panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) on (lagged) options volume (*Optvol*) and other (lagged) firm-level control variables. Firms in all columns: 526 in Panel A and 399 in Panel B. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Method	OLS		NB		Poisson	
Dependent var.	Ln(1+CITES)	Ln(1+PATS)	CITES	PATS	CITES	PATS
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: One-year lag						
Ln(Optvol)	0.185***	0.179***	0.181***	0.152***	0.146***	0.123**
	(0.033)	(0.028)	(0.033)	(0.027)	(0.047)	(0.056)
InstOwn	-0.108	-0.215	0.002	0.025	-0.103	-0.024
	(0.182)	(0.162)	(0.202)	(0.172)	(0.215)	(0.204)
Ln(K/L)	0.023	0.042	0.078	0.151**	0.610***	0.463***
	(0.060)	(0.050)	(0.079)	(0.067)	(0.191)	(0.170)
Ln(Sales)	0.123***	0.126***	0.132***	0.152***	0.147	0.170**
	(0.044)	(0.036)	(0.043)	(0.040)	(0.090)	(0.072)
Ln(Age)	-0.116	-0.059	-0.215**	-0.258***	-0.353***	-0.385***
	(0.090)	(0.077)	(0.100)	(0.082)	(0.104)	(0.091)
Ln(R&D stock)	0.255***	0.200***	0.311***	0.265***	0.146	0.242**
	(0.050)	(0.046)	(0.047)	(0.045)	(0.105)	(0.101)
Observations	2,658	2,658	2,658	2,658	2,658	2,658
Panel B: Three-year lag						
Ln(Optvol)	0.130***	0.179***	0.138***	0.164***	0.157***	0.132**
	(0.042)	(0.039)	(0.044)	(0.033)	(0.049)	(0.061)
InstOwn	-0.058	-0.194	0.142	0.027	-0.064	0.099
	(0.222)	(0.201)	(0.243)	(0.192)	(0.265)	(0.213)
Ln(K/L)	0.005	0.048	0.179**	0.143**	0.733***	0.578***
	(0.068)	(0.062)	(0.084)	(0.070)	(0.222)	(0.174)
Ln(Sales)	0.159***	0.158***	0.186***	0.167***	0.153	0.205***
	(0.047)	(0.042)	(0.054)	(0.042)	(0.115)	(0.076)
Ln(Age)	-0.099	-0.105	-0.211*	-0.294***	-0.409***	-0.452***
	(0.099)	(0.091)	(0.112)	(0.083)	(0.120)	(0.092)
Ln(R&D stock)	0.215***	0.170***	0.259***	0.236***	0.118	0.182*
	(0.051)	(0.051)	(0.053)	(0.048)	(0.122)	(0.105)
Observations	1,687	1,687	1,687	1,687	1,687	1,687

Table A4

Options volume and innovation–Monotonic relationship?

This table presents estimates of OLS, NB, and Poisson panel regressions of firms' patents weighted by the number of forward citations (*CITES*) on options volume (*Optvol*), its squared term, a dummy variable for high options volume (*High Optvol*), its interaction with options volume, and other firm-level control variables. *High Optvol* equals one if the options volume for a given firm is above the median in year t and zero otherwise. Firms in all columns: 548. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Method	OLS		NB		Poisson	
Dependent var.	Ln(1+CITES)	Ln(1+CITES)	CITES	CITES	CITES	CITES
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Optvol)		0.065		-0.012		-0.045
x High Optvol		(0.069)		(0.067)		(0.072)
High Optvol		-0.159		0.042		0.166
		(0.269)		(0.251)		(0.259)
Ln(Optvol)	0.009		-0.003		-0.011	
x Ln(Optvol)	(0.008)		(0.008)		(0.008)	
Ln(Optvol)	0.105*	0.127***	0.176***	0.162***	0.254***	0.184***
	(0.059)	(0.044)	(0.060)	(0.046)	(0.074)	(0.059)
InstOwn	-0.017	-0.024	0.066	0.068	-0.126	-0.103
	(0.159)	(0.159)	(0.178)	(0.178)	(0.222)	(0.222)
Ln(K/L)	0.025	0.024	0.107	0.106	0.540***	0.553***
	(0.052)	(0.052)	(0.067)	(0.067)	(0.172)	(0.172)
Ln(Sales)	0.127***	0.127***	0.135***	0.135***	0.140*	0.128*
	(0.041)	(0.041)	(0.040)	(0.040)	(0.072)	(0.075)
Ln(Age)	-0.107	-0.106	-0.213**	-0.213**	-0.326***	-0.328***
	(0.084)	(0.084)	(0.095)	(0.095)	(0.102)	(0.102)
Ln(R&D stock)	0.253***	0.253***	0.301***	0.300***	0.159*	0.164*
	(0.046)	(0.046)	(0.042)	(0.042)	(0.085)	(0.086)
Observations	3,271	3,271	3,271	3,271	3,271	3,271

Table A5
Options volume and innovation–Contemporaneous R&D spending.

This table presents estimates of OLS, NB, and Poisson panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and firms' unweighted patent counts (*PATS*) on options volume (*Optvol*), contemporaneous R&D spending (*XRD*), and other firm-level control variables. Firms in all columns: 548. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Method	OLS		NB		Poisson	
Dependent var.	Ln(1+CITES)	Ln(1+PATS)	CITES	PATS	CITES	PATS
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Optvol)	0.140***	0.136***	0.133***	0.122***	0.141***	0.091*
	(0.030)	(0.025)	(0.029)	(0.025)	(0.043)	(0.052)
InstOwn	-0.041	-0.218	0.021	-0.032	-0.084	-0.039
	(0.156)	(0.137)	(0.177)	(0.147)	(0.207)	(0.214)
Ln(K/L)	0.026	0.042	0.099	0.141**	0.562***	0.430***
	(0.052)	(0.044)	(0.065)	(0.058)	(0.171)	(0.164)
Ln(Sales)	0.100**	0.095***	0.131***	0.132***	0.078	0.094
	(0.042)	(0.034)	(0.042)	(0.039)	(0.070)	(0.064)
Ln(Age)	-0.040	0.024	-0.144	-0.151**	-0.298***	-0.291***
	(0.082)	(0.067)	(0.093)	(0.075)	(0.109)	(0.103)
Ln(1+XRD)	0.316***	0.256***	0.331***	0.290***	0.224**	0.349***
	(0.052)	(0.046)	(0.048)	(0.047)	(0.093)	(0.084)
Observations	3,271	3,271	3,271	3,271	3,271	3,271

Table A6

Options volume and innovation–R&D stock dummy variables.

This table presents estimates of OLS, NB, and Poisson panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) on options volume (*Optvol*), *R&D stock* dummy variables based on deciles of its distribution, and other firm-level control variables. Firms in all columns: 548. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Method	OLS		NB		Poisson	
Dependent var.	Ln(1+CITES)	Ln(1+PATS)	CITES	PATS	CITES	PATS
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Optvol)	0.163***	0.145***	0.149***	0.132***	0.147***	0.115***
	(0.029)	(0.024)	(0.028)	(0.024)	(0.032)	(0.043)
InstOwn	-0.088	-0.188	0.073	-0.039	-0.271	-0.187
	(0.166)	(0.140)	(0.176)	(0.146)	(0.217)	(0.220)
Ln(K/L)	0.024	0.035	0.100	0.144**	0.473***	0.381**
	(0.053)	(0.043)	(0.067)	(0.058)	(0.152)	(0.156)
Ln(Sales)	0.105***	0.081**	0.095**	0.093**	0.144**	0.177***
	(0.040)	(0.033)	(0.039)	(0.037)	(0.067)	(0.062)
Ln(Age)	-0.131	-0.067	-0.255***	-0.244***	-0.258***	-0.296***
	(0.083)	(0.067)	(0.095)	(0.075)	(0.094)	(0.096)
R&D stock, 10%	Benchmark	Benchmark	Benchmark	Benchmark	Benchmark	Benchmark
R&D stock, 20%	0.162	-0.096	0.119	-0.125	0.028	-0.259
	(0.145)	(0.090)	(0.161)	(0.132)	(0.187)	(0.220)
R&D stock, 30%	0.533***	0.174*	0.648***	0.332**	0.265	0.172
	(0.145)	(0.099)	(0.160)	(0.132)	(0.191)	(0.229)
R&D stock, 40%	0.648***	0.257**	0.578***	0.423***	0.207	0.323
	(0.154)	(0.113)	(0.168)	(0.137)	(0.199)	(0.237)
R&D stock, 50%	0.793***	0.347***	0.668***	0.621***	0.425**	0.567**
	(0.180)	(0.134)	(0.177)	(0.160)	(0.206)	(0.255)
R&D stock, 60%	0.784***	0.480***	0.887***	0.829***	0.436*	0.638**
	(0.182)	(0.140)	(0.184)	(0.160)	(0.229)	(0.260)
R&D stock, 70%	0.959***	0.635***	1.106***	0.998***	0.625***	0.805***
	(0.192)	(0.155)	(0.201)	(0.170)	(0.231)	(0.265)
R&D stock, 80%	1.259***	0.804***	1.379***	1.135***	0.941***	1.065***
	(0.206)	(0.175)	(0.210)	(0.185)	(0.234)	(0.275)
R&D stock, 90%	1.611***	1.285***	1.881***	1.610***	1.156***	1.438***
	(0.251)	(0.225)	(0.244)	(0.219)	(0.305)	(0.312)
R&D stock, 100%	1.858***	1.613***	2.260***	1.975***	0.966**	1.523***
	(0.316)	(0.302)	(0.296)	(0.284)	(0.383)	(0.376)
Observations	3,271	3,271	3,271	3,271	3,271	3,271

Table A7
Options volume and innovation–Internet bubble.

This table presents estimates of OLS, NB, and Poisson panel regressions of firms' patents weighted by the number of forward citations (*CITES*) on options volume (*Optvol*) and other firm-level control variables for the two subperiods 1996 – 2000 (during the "dot-com bubble") and 2001 – 2004 (after the "dot-com bubble"). Firms in columns: 501 in columns 1 – 3 and 398 in columns 4 – 6. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Period	"1996 – 2000"			"2001 – 2004"		
Method	OLS	NB	Poisson	OLS	NB	Poisson
Dependent var.	Ln(1+CITES)	CITES	CITES	Ln(1+CITES)	CITES	CITES
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Optvol)	0.176***	0.134***	0.149***	0.161***	0.164***	0.179**
	(0.035)	(0.031)	(0.039)	(0.037)	(0.045)	(0.070)
InstOwn	0.002	0.089	-0.131	-0.303	-0.018	0.179
	(0.188)	(0.170)	(0.209)	(0.185)	(0.280)	(0.443)
Ln(K/L)	0.026	0.086	0.533***	0.048	0.125	0.769***
	(0.066)	(0.072)	(0.170)	(0.060)	(0.098)	(0.224)
Ln(Sales)	0.173***	0.144***	0.127	0.061	0.095	0.049
	(0.049)	(0.042)	(0.078)	(0.042)	(0.065)	(0.088)
Ln(Age)	-0.256***	-0.284***	-0.334***	0.121	-0.026	-0.291*
	(0.096)	(0.091)	(0.097)	(0.098)	(0.137)	(0.176)
Ln(R&D stock)	0.260***	0.291***	0.167*	0.243***	0.372***	0.205**
	(0.054)	(0.040)	(0.094)	(0.049)	(0.075)	(0.101)
Observations	1,906	1,906	1,906	1,365	1,365	1,365

Table A8
Options volume and innovation–Additional (financial) controls.

This table presents estimates of OLS, NB, and Poisson panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) on options volume (*Optvol*) and other (additional) firm-level control variables. *Illiquidity* is the natural logarithm of the relative effective spread measured over firm i's fiscal year t, where the relative effective spread is defined as the absolute value of the difference between the execution price and the midpoint of the prevailing bid-ask quote divided by the midpoint of the prevailing bid-ask quote; *Leverage* is the book value of debt (DLTT+DLC) divided by the book value of assets (AT); *Tobin's Q* is calculated as (market value of equity (PRCC_F × CSHO) plus the book value of assets (AT) minus the book value of equity (CEQ) minus balance sheet deferred taxes (TXDB)) divided by the book value of assets (AT); *ROA* is operating income before depreciation (OIDBP) divided by the book value of assets (AT); *Capex* is defined as capital expenditures (CAPX) scaled by the book value of assets (AT); and *Analyst coverage* is the arithmetic mean of the 12 monthly numbers of earnings forecasts for firm i extracted from the I/B/E/S summary file. Firms in all columns: 548. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Method	OLS		NB		Poisson	
Dependent var.	Ln(1+CITES)	Ln(1+PATS)	CITES	PATS	CITES	PATS
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Optvol)	0.110***	0.097***	0.118***	0.099***	0.152***	0.104**
	(0.022)	(0.019)	(0.023)	(0.020)	(0.044)	(0.051)
InstOwn	0.005	-0.290	-0.184	-0.212	-0.340	-0.226
	(0.242)	(0.183)	(0.299)	(0.210)	(0.298)	(0.292)
Ln(K/L)	-0.077	0.018	0.041	0.089	0.373***	0.255***
	(0.070)	(0.054)	(0.096)	(0.073)	(0.128)	(0.084)
Ln(Sales)	0.064	0.048	0.069	0.047	-0.177	0.045
	(0.060)	(0.045)	(0.059)	(0.053)	(0.117)	(0.088)
Ln(Age)	-0.041	0.048	-0.097	-0.064	-0.285**	-0.281**
	(0.113)	(0.086)	(0.122)	(0.091)	(0.131)	(0.124)
Ln(R&D stock)	0.274***	0.254***	0.269***	0.304***	0.492***	0.473***
	(0.069)	(0.054)	(0.061)	(0.059)	(0.118)	(0.085)
Illiquidity	-0.109*	-0.136**	-0.173**	-0.162***	-0.088	-0.032
	(0.062)	(0.052)	(0.068)	(0.055)	(0.086)	(0.067)
Leverage	0.548*	0.280	0.500	0.254	0.315	0.003
	(0.296)	(0.229)	(0.338)	(0.236)	(0.402)	(0.451)
Tobin's Q	-0.073	-0.047	-0.135	-0.085	-0.038	0.105
	(0.082)	(0.059)	(0.085)	(0.063)	(0.111)	(0.118)
ROA	-0.553	-0.531**	-0.871**	-0.758***	0.716	-0.205
	(0.373)	(0.251)	(0.361)	(0.286)	(0.449)	(0.448)
Capex	1.613	0.087	-0.344	-0.402	0.564	1.196
	(1.041)	(0.758)	(0.995)	(0.801)	(0.952)	(1.188)
Ln(1+Analyst coverage)	-0.003	0.044	0.029	0.050	0.070	0.039
	(0.080)	(0.064)	(0.083)	(0.064)	(0.073)	(0.058)
Observations	3,271	3,271	3,271	3,271	3,271	3,271

Table A9
Options volume and innovation–External knowledge acquisition.

This table presents estimates of OLS panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) on options volume (*Optvol*), *collaboration frequency*, *collaboration intensity*, *acquisitions*, and other firm-level control variables. *Collaboration frequency* is the natural logarithm of (one plus) the number of R&D alliances formed over the previous five years (i.e., from $t-5$ to $t-1$); *Collaboration intensity* is the number of a firm's jointly owned patents filed over the previous five years scaled by its total number of patents filed over the same period; and *Acquisitions* is the acquisition expenditure (ACQ) divided by the book value of assets (AT). Firms in columns: 236 in columns 1 and 2; 548 in columns 3 – 6. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Control variable	Collaboration frequency		Collaboration intensity		Acquisitions	
Dependent var.	Ln(1+CITES)	Ln(1+PATS)	Ln(1+CITES)	Ln(1+PATS)	Ln(1+CITES)	Ln(1+PATS)
Method: OLS	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Optvol)	0.107***	0.090***	0.116***	0.158***	0.114***	0.156***
	(0.020)	(0.017)	(0.019)	(0.024)	(0.019)	(0.024)
InstOwn	-0.186	-0.252*	-0.164	-0.224	-0.153	-0.211
	(0.152)	(0.139)	(0.153)	(0.141)	(0.152)	(0.139)
Ln(K/L)	-0.012	0.040	-0.011	0.042	-0.014	0.040
	(0.048)	(0.043)	(0.049)	(0.044)	(0.048)	(0.044)
Ln(Sales)	0.129***	0.122***	0.121***	0.111***	0.130***	0.122***
	(0.036)	(0.033)	(0.037)	(0.034)	(0.036)	(0.033)
Ln(Age)	-0.062	-0.032	-0.059	-0.032	-0.057	-0.027
	(0.077)	(0.069)	(0.078)	(0.069)	(0.077)	(0.069)
Ln(R&D stock)	0.250***	0.193***	0.263***	0.210***	0.259***	0.204***
	(0.041)	(0.043)	(0.042)	(0.044)	(0.042)	(0.043)
Collaboration freq.	0.106***	0.129***				
	(0.035)	(0.032)				
Collaboration int.			-0.731*	-0.923***		
			(0.393)	(0.303)		
Acquisitions					-0.570**	-0.539**
					(0.290)	(0.257)
Observations	1,446	1,446	3,271	3,271	3,271	3,271

Table A10
Options volume and innovation–High- versus low-tech industries.

This table presents estimates of OLS panel regressions on a matched sample of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) on options volume *(Optvol)*, a dummy variable that equals one if a firm is operating in a high-tech industry (*Dummy for high-tech*), their interaction, and other firm-level control variables. Firms in the matched sample: 547. Firms in columns 3 and 7: 311. Firms in columns 4 and 8: 236. Robust standard errors are clustered by firm (in parentheses). The matched sample is constructed using nearest-neighbor matching with scores given by a probit model in which the dependent variable is *Dummy for high-tech*. The propensity score is estimated using the following firm characteristics: *Ln(Optvol)*, *InstOwn*, *Ln(K/L)*, *Ln(Sales)*, *Ln(Age)*, *Ln(R&D stock)*, *Illiquidity*, *Leverage*, *Tobin's Q*, *ROA*, *Capex*, *Ln(Analyst coverage)*, and fixed effects. All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Dependent var.	Ln(1+CITES)				Ln(1+PATS)			
Matched sample	All	All	High-tech	Low-tech	All	All	High-tech	Low-tech
Method: OLS	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(Optvol)		0.186***				0.193***		
x Dummy for high-tech		(0.059)				(0.056)		
Ln(Optvol)	0.120***	0.004	0.144***	0.070	0.113***	-0.007	0.147***	0.046
	(0.039)	(0.052)	(0.049)	(0.058)	(0.034)	(0.049)	(0.040)	(0.051)
Dummy for high-tech	1.219**	0.932*			0.543	0.243		
	(0.485)	(0.510)			(0.578)	(0.605)		
InstOwn	-0.092	-0.053	-0.148	0.199	-0.164	-0.123	-0.287	0.208
	(0.189)	(0.188)	(0.248)	(0.252)	(0.170)	(0.170)	(0.231)	(0.216)
Ln(K/L)	-0.068	-0.071	0.085	-0.252*	-0.023	-0.025	0.090	-0.166
	(0.098)	(0.097)	(0.134)	(0.143)	(0.079)	(0.079)	(0.111)	(0.109)
Ln(Sales)	0.104*	0.091	0.180**	-0.076	0.100*	0.086*	0.163**	-0.031
	(0.062)	(0.062)	(0.087)	(0.081)	(0.053)	(0.052)	(0.075)	(0.065)
Ln(Age)	-0.138	-0.150*	-0.155	-0.156	-0.099	-0.111	-0.114	-0.119
	(0.085)	(0.084)	(0.113)	(0.118)	(0.073)	(0.072)	(0.097)	(0.102)
Ln(R&D stock)	0.167***	0.167***	0.212***	0.099**	0.143***	0.143***	0.158***	0.114***
	(0.034)	(0.034)	(0.050)	(0.043)	(0.028)	(0.027)	(0.041)	(0.035)
Observations	2,906	2,906	1,453	1,453	2,906	2,906	1,453	1,453

Table A11
Options volume and innovation–Within-firm relationship.

This table presents estimates of OLS panel regressions of within-firm changes in patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) before and after the option listing event. *Post* is a dummy variable equal to unity to indicate the post-listing period; *Inclusion year #* are dummy variables indicating the relative year around the listing event (the omitted category is the year of the event). Firms in columns: 93. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Dependent var.	Ln(1+CITES)		Ln(1+PATS)	
Method: OLS	(1)	(2)	(3)	(4)
Post	0.370**		0.277*	
	(0.146)		(0.118)	
Inclusion year −3		0.240		0.008
		(0.154)		(0.080)
Inclusion year −2		0.207		0.084
		(0.144)		(0.075)
Inclusion year −1		0.313**		0.135
		(0.142)		(0.098)
Inclusion year 1		0.243*		0.116
		(0.131)		(0.078)
Inclusion year 2		0.568***		0.271***
		(0.148)		(0.103)
Inclusion year 3		0.636***		0.335***
		(0.145)		(0.114)
Inclusion year 4		0.558***		0.526***
		(0.162)		(0.124)
InstOwn	-0.088	0.010	-0.159	-0.111
	(0.257)	(0.256)	(0.245)	(0.241)
Ln(K/L)	-0.058	-0.061	-0.011	-0.014
	(0.073)	(0.074)	(0.061)	(0.062)
Ln(Sales)	0.196***	0.198***	0.133***	0.134***
	(0.052)	(0.053)	(0.044)	(0.045)
Ln(Age)	-0.225**	-0.225**	-0.072	-0.070
	(0.112)	(0.112)	(0.087)	(0.087)
Ln(R&D stock)	0.211***	0.218***	0.252***	0.255***
	(0.043)	(0.044)	(0.048)	(0.048)
Observations	744	614	744	614

Table A12
Open interest as instrumental variable.

This table presents estimates of 2SLS panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) on options volume (*Optvol*) and other firm-level control variables, with the total open interest *Ln(Open int.)* as an instrumental variable. Firms in all columns: 548. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The time period is 1996 – 2004 (with citations up to 2006). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Method	OLS (first stage)	2SLS (second stage)	
Dependent var.	Ln(Optvol)	Ln(1+CITES)	Ln(1+PATS)
	(1)	(2)	(3)
Ln(Optvol) *(instr.)*		0.087***	0.102***
		(0.029)	(0.024)
InstOwn	1.185***	-0.028	-0.218
	(0.140)	(0.156)	(0.137)
Ln(K/L)	-0.205***	0.015	0.039
	(0.053)	(0.053)	(0.045)
Ln(Sales)	0.242***	0.156***	0.133***
	(0.028)	(0.041)	(0.033)
Ln(Age)	-0.412***	-0.121	-0.036
	(0.065)	(0.083)	(0.068)
Ln(R&D stock)	0.056**	0.273***	0.217***
	(0.028)	(0.046)	(0.044)
Ln(Open int.)	1.207***		
	(0.028)		
Observations	3,271	3,271	3,271

Table A13
Interaction with managerial entrenchment (E-Index).

This table presents estimates of OLS panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*), managerial entrenchment (*E-Index*), their interaction, and other firm-level control variables. Firms in columns: 331. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of three-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). The E-Index is an average of six provisions in the firm's charter (see Bebchuk, Cohen, and Ferrell, 2009). The measure is based on data from RiskMetrics from 1998, 2000, 2002, and 2004. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Dependent var.	Ln(1+CITES)		Ln(1+PATS)	
Method: OLS	(1)	(2)	(3)	(4)
Ln(Optvol)		-0.032**		-0.031**
x E-Index		(0.015)		(0.013)
Ln(Optvol)	0.168***	0.160***	0.151***	0.144***
	(0.031)	(0.031)	(0.028)	(0.028)
E-Index	-0.014	0.012	-0.016	0.009
(entrenchment index)	(0.034)	(0.034)	(0.029)	(0.029)
InstOwn	-0.020	-0.048	-0.015	-0.041
	(0.192)	(0.193)	(0.170)	(0.170)
Ln(K/L)	0.106	0.107	0.075	0.076
	(0.070)	(0.069)	(0.059)	(0.058)
Ln(Sales)	0.108**	0.103**	0.126***	0.120***
	(0.047)	(0.047)	(0.044)	(0.044)
Ln(Age)	-0.183**	-0.173*	-0.106	-0.098
	(0.090)	(0.090)	(0.084)	(0.084)
Ln(R&D stock)	0.126***	0.124***	0.116***	0.114***
	(0.028)	(0.028)	(0.024)	(0.024)
Observations	921	921	921	921

Table A14
Innovation and Tobin's Q.

This table presents estimates of OLS regressions of firms' market value (*Tobin's Q*) on firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*), *one-year lagged Tobin's Q*, options volume (*Optvol*), and other firm-level control variables. Firms in all columns: 526. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies and time dummies. The time period is 1996–2004 (with citations up to 2006); * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Dependent var.: Tobin's Q		
Method: OLS	(1)	(2)
Ln(1+CITES)	0.050*	
	(0.026)	
Ln(1+PATS)		0.059*
		(0.033)
One-year lagged Tobin's Q	0.383***	0.383***
	(0.049)	(0.049)
Ln(Optvol)	0.236***	0.236***
	(0.037)	(0.037)
InstOwn	-0.052	-0.041
	(0.202)	(0.202)
Ln(K/L)	0.057	0.054
	(0.106)	(0.106)
Ln(Sales)	-0.221***	-0.225***
	(0.069)	(0.071)
Ln(Age)	-0.173	-0.175
	(0.112)	(0.111)
Ln(R&D stock)	0.030	0.028
	(0.039)	(0.039)
Leverage	-1.625***	-1.610***
	(0.297)	(0.295)
ROA	1.823***	1.830***
	(0.641)	(0.638)
Capex	0.598	0.634
	(2.470)	(2.476)
Observations	2,658	2,658

Table A15
Controlling for possible mechanisms.

This table presents estimates of OLS panel regressions of firms' patents weighted by the number of forward citations (*CITES*) and unweighted patent counts (*PATS*) on product market competition (*Competition*), managerial entrenchment (*G-Index*), *CEO age*, lagged change in profitability (Δ ROA_{t-1}), stock-based compensation (*CEO vega* and *CEO delta*), and other firm-level control variables. Firms in columns: 285. Robust standard errors are clustered by firm (in parentheses). All regressions control for a full set of four-digit industry dummies, time dummies, and fixed effects by including pre-sample means of the dependent variable as proposed by Blundell, Griffith, and Van Reenen (1999). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Dependent var.	Ln(1+CITES)		Ln(1+PATS)	
Method: OLS	(1)	(2)	(3)	(4)
Ln(Optvol)	0.216***	0.154***	0.192***	0.155***
	(0.050)	(0.050)	(0.042)	(0.043)
Competition		8.454***		5.384***
(1 − Lerner)		(2.619)		(1.764)
G-Index		-0.033		-0.032
(governance index)		(0.028)		(0.025)
Ln(CEO age)		-0.807**		-0.605*
		(0.396)		(0.325)
Δ ROA$_{t-1}$		-0.162		-0.123
		(0.406)		(0.307)
Ln(CEO vega)		0.038		0.113***
		(0.054)		(0.041)
Ln(CEO delta)		0.072		0.044
		(0.055)		(0.046)
InstOwn	-0.072	-0.092	-0.139	-0.145
	(0.293)	(0.296)	(0.259)	(0.266)
Ln(K/L)	0.023	0.055	0.079	0.099
	(0.102)	(0.101)	(0.084)	(0.080)
Ln(Sales)	0.231***	0.248***	0.227***	0.240***
	(0.082)	(0.080)	(0.072)	(0.071)
Ln(Age)	-0.147	-0.122	-0.102	-0.068
	(0.154)	(0.154)	(0.142)	(0.140)
Ln(R&D stock)	0.140**	0.142**	0.080	0.082
	(0.062)	(0.061)	(0.059)	(0.058)
Observations	1,530	1,530	1,530	1,530

Table A16
Descriptive statistics (robustness tests).
This table reports summary statistics for variables used in the robustness tests.

	Mean	StdDev	Min	Median	Max	Observations	Source
Co-patents/Patents$_{[t-5,t-1]}$	0.03	0.09	0	0	1	2,391	USPTO
Leverage	0.16	0.16	0	0.13	0.91	3,271	Compustat
Tobin's Q	3.0	2.8	0.40	2.1	39.1	3,271	Compustat
Capex/Assets	0.05	0.05	0.00003	0.04	0.53	3,271	Compustat
Acquisition exp. (in $m)	85.1	458	-3,557	0	8,800	3,271	Compustat
Open interest	396	1,056	0.03	92.4	13,267	3,271	OptionMetrics
Stock illiquidity	-5.5	2.1	-11.6	-5.5	2.9	3,271	TAQ
Analyst coverage	8.4	7.9	0	6.1	45.6	3,271	I/B/E/S
R&D alliances$_{[t-5,t-1]}$	3.7	15.2	0	0	270	1,446	SDC Platinum
Entrenchment index	2.1	1.1	0	2	5	921	RiskMetrics and Bebchuk et al. (2009)
CEO tenure	7.3	7.9	0	5	53	1,845	ExecuComp
CEO cash comp. (in $000s)	1,340	1,492	0	962	43,512	1,845	ExecuComp