

Internet Appendix for: Does Going Public Affect Innovation?

July 3, 2014

I Variable Definitions

Innovation Measures

1. *Citations* - Number of citations a patent receives in its grant year and the following three calendar years.
2. *Generality* - A patent that is being cited by a broader array of technology classes is viewed as having greater generality. Generality is calculated as the Herfindahl index of *citing* patents, used to capture the dispersion across technology classes of patents using the patent. To account for cases with a small number of patents within technology classes, I use the bias correction described in Jaffe and Trajtenberg (2002).
3. *Originality* - A patent that cites a broader array of technology classes is viewed as having greater originality. Originality is calculated as the Herfindahl index of *cited* patents, used to capture dispersion of the patent citations across technology classes. To account for cases with a small number of patents within technology classes, I use the bias correction described in Jaffe and Trajtenberg (2002).
4. *Scaled Citations* - Number of citations a patent receives divided by the average number of citations received by all patents granted in the same year and technology class.
5. *Scaled Generality* - Generality measure of a patent divided by the average generality of all patents granted in the same year and technology class.
6. *Scaled Originality* - Originality measure of a patent divided by the average originality of all patents granted in the same year and technology class.
7. *Scaled Number of Patents* - Each patent is adjusted for variations in patent filings likelihood and for truncation bias. The truncation bias in patent grants stems from the lag in patent approval (of about two years). Thus, towards the end of the sample, patents under report the actual patenting since many patents, although applied for,

might not have been granted. Following Hall, Jaffe, and Trajtenberg (2001), the bias is corrected by dividing each patent by the average number of patents of all firms in the same year and technology class.

8. *Technology Class* - A technology class is a detailed classification of the U.S. Patenting and Trademark Office (USPTO) which clusters patents based on similarity in the essence of their technological innovation. Technological classes are often more detailed than industry classifications, consisting of about 400 main (3-digit) patent classes, and over 120,000 patent subclasses. For example, within the communications category, there are various technology classes such as: wave transmission lines and networks, electrical communications, directive radio wave systems and devices, radio wave antennas, multiplex communications, optical wave guides, etc.

IPO Characteristics

9. *Firm Age* - Firm age at the year of the IPO filing, calculated from the founding date.
10. *Early Follower* - An indicator variable that captures the location of a filer within the IPO wave. Following Beneveniste et al. (2003), a filer is considered an early follower if filed within 180 days of a pioneer in the same Fama-French 48 industry.
11. *Pioneer* - An indicator variable that captures the location of a filer within the IPO wave. Following Beneveniste et al. (2003), a filer is considered a pioneer if its filing is not preceded by an IPO filing in the same Fama-French 48 industry in the previous 180 days.
12. *Lead Underwriter Ranking* - A ranking of the lead underwriter on a scale of 0 to 9, where 9 is the highest underwriter prestige. The ranking is compiled by Carter and Manaster (1990), Carter, Dark, and Singh (1998), and Loughran and Ritter (2004).
13. *VC-Backed* - An indicator is equal to one if the firm was funded by a venture capital firm at the time of the IPO filing.
14. *Post-filing NASDAQ returns* - The two-month NASDAQ returns calculated from the day of the IPO filing.
15. *Pre-filing NASDAQ returns* - The three-month NASDAQ returns leading to the IPO filing date.

Financial Characteristics at IPO filing

16. *Log Total Assets* - the natural logarithm of the total book value of assets.
17. *R&D / Assets* - the ratio of R&D expenditure to book value of assets.
18. *Net Income / Assets* - the ratio of net income to book value of assets.
19. *Cash / Assets* - the ratio of cash holdings to book value of assets.

II Simple Example of Instrumental Variables Analysis

To illustrate the advantage of using this instrumental variables approach consider a simple example.¹ Assume that firm innovation following the IPO filing is the sum of future innovation opportunities (which are unobserved at the time of the IPO filing) and the effect of ownership structure (being public or private). Specifically, the post-IPO innovative performance can be written as $Q + c \cdot IPO$, where Q stands for the unobserved quality of the issuer's future innovative projects, and IPO is a dummy that indicates whether the issuer completed the IPO filing ($IPO = 1$) or remained private ($IPO = 0$). The goal is to estimate c , the effect of public ownership on firm innovation.

Suppose that the unobserved quality of future projects is heterogeneous and affects the likelihood of completing the IPO filing. Specifically, there are three types of firms: *Sure Thing* firms, with highest-quality of future innovative projects ($Q = q_H$), will complete the IPO irrespective of book-building market conditions; *Sensitive* firms, with medium-quality innovative projects ($Q = q_M$), will not complete the IPO filing if NASDAQ drops during the book-building phase, but will go public otherwise; and *Long Shot* firms, with the poorest innovative prospects ($Q = q_L$), will withdraw irrespective of the NASDAQ change.² For simplicity, assume that NASDAQ can be either *high* or *low* each with probability of $1/2$, and firm types are equally likely. The table below summarizes the innovative outcomes in the six cases:³

¹This example is based on Bennedsen et al. (2012)

²The decision to withdraw or complete the IPO filing is complicated and driven by many observed and unobserved factors. For simplicity, in this example I assume that the decision depends only on one factor, the unobserved quality of innovative projects.

³I assume in this example that innovative opportunities (i.e., q_H, q_M, q_L), are independent of NASDAQ fluctuations. This assumption is part of the exclusion restriction, which I discuss in detail in section 2.C.

Firm Type	NASDAQ returns	
	High	Low
Sure Thing	<i>Complete</i> $q_H + c$	<i>Complete</i> $q_H + c$
Sensitive	<i>Complete</i> $q_M + c$	<i>Withdraw</i> q_M
Long Shot	<i>Withdraw</i> q_L	<i>Withdraw</i> q_L

The OLS estimate simply compares firms that completed the IPO filing (the upper triangle) and firms that withdrew the IPO filing (the bottom triangle) and reflects the sum of the IPO effect as well as a selection bias:

$$(1) \quad \gamma_{OLS} = E[Y|IPO = 1] - E[Y|IPO = 0] = c + \frac{2}{3}(q_H - q_L) > c$$

Thus OLS will overestimate the effect of going public in this example because better firms are more likely to complete the IPO filing.⁴

The instrumental variables approach uses the variation in the NASDAQ – which affects the decision to complete the IPO filing – to estimate the effects of an IPO on innovative outcomes. Specifically, simply comparing outcomes based on the NASDAQ returns generates the “reduced-form” regression which is equivalent to calculating the difference in performance across columns:

$$(2) \quad E[Y|NSDQ = High] - E[Y|NSDQ = Low] = \frac{1}{3}c$$

The “first-stage” regression captures the likelihood to complete the IPO as a function of the

⁴If one assumes that lower quality firms are more likely to complete the IPO filing then the sign of the bias reverses.

NASDAQ variation:

$$(3) \quad E[IPO|NSDQ = High] - E[IPO|NSDQ = Low] = \frac{1}{3}$$

Scaling the reduced-form result by the first-stage regression coefficient generates the desired outcome:

$$(4) \quad \gamma_{IV} = \frac{E[Y|NSDQ = High] - E[Y|NSDQ = Low]}{E[IPO|NSDQ = High] - E[IPO|NSDQ = Low]} = c$$

The example illustrates that the IV estimator uses only the *sensitive* firms whose IPO completion depends on NASDAQ conditions. In other words, the estimates are coming from a comparison of IPO and withdrawn firms that belong to the sensitive group. In fact, this is a general result, as any instrumental variables estimator uses only the information of the group of firms that responds to the instrument (Imbens and Angrist, 1994).

In the example I assumed for the sake of simplicity that NASDAQ returns can take two values. Clearly, NASDAQ returns vary considerably. When the instrument is multi-valued, the IV estimate is a weighted average of the sensitive subpopulation estimates along the support of the instrument (Angrist and Imbens, 1995).⁵

⁵Different firms have different thresholds of NASDAQ changes for which they complete the IPO filing. Roughly speaking, the IV estimate is an average of the estimates of sensitive firms along different values of NASDAQ returns. The average is weighted by the impact of NASDAQ returns on completing the IPO filing, and by the likelihood of observing the NASDAQ returns.

III Additional Tables

Table A.1 - Additional Summary Statistics

Table reports summary statistics of the key variables of the analysis. Panel A describes the distribution of IPO filings and patents over time. Panels B and C detail the distribution of firms across industries and the distribution of patents across technology classes. The industry classification is based on Fama-French 10, and the technology classification is based on Hall, Jaffe, and Trajtenberg (2001).

Panel A - Distribution by year

Year	IPO Filings		Patent Applications		Patent Grants	
	Complete	Withdrawn	Complete	Withdrawn	Complete	Withdrawn
1983	N/A	N/A	4	2	0	0
1984	N/A	N/A	18	9	1	0
1985	4	2	16	8	9	8
1986	10	5	58	18	9	5
1987	11	6	111	17	39	11
1988	14	4	202	34	62	13
1989	42	6	356	74	147	27
1990	34	10	527	86	231	56
1991	120	2	715	62	321	59
1992	119	33	1169	125	525	68
1993	144	14	1457	106	797	89
1994	105	18	2152	162	1050	87
1995	140	8	3568	318	1309	94
1996	169	29	3220	262	1760	133
1997	114	25	3857	444	2298	199
1998	66	20	3672	509	3317	310
1999	169	15	4249	634	3658	388
2000	167	95	4225	586	3360	457
2001	17	13	4144	555	3448	531
2002	12	17	3082	431	3483	517
2003	21	1	1795	256	3678	533
2004	N/A	N/A	616	117	3547	465
2005	N/A	N/A	89	20	2943	376
2006	N/A	N/A	4	0	3314	409
Total	1478	323	39306	4835	39306	4835

Panel B - Distribution by industry

Industry	Complete	Withdrawn
Consumer Non-Durables	2.77%	3.10%
Consumer Durables	3.04%	2.17%
Manufacturing	10.15%	11.46%
Oil, Gas, and Coal Extraction	0.74%	0.93%
Computers, Software, and Electronic Equipment	49.32%	39.94%
Telephone and Television Transmission	1.89%	3.10%
Wholesale, Retail	2.71%	4.95%
Healthcare, Medical Equipment, and Drugs	24.22%	29.10%
Utilities	0.41%	0.31%
Other (Mines, Construction, Hotels, etc.)	4.74%	4.95%

Panel C - Distribution of patents across technology classes

Technology Class	Complete	Withdrawn
Chemical	9.43%	11.15%
Computers and Communication	35.11%	26.29%
Drugs and Medicine	21.84%	28.25%
Electronics	18.57%	17.91%
Mechanical	8.67%	7.40%
Other	6.38%	9.00%

Table A.2 - Within-firm relationship between IPOs and Innovation

Table presents within-firm changes in innovative activity around the IPO of firms that completed the IPO filing. The dependent variables are stated at the top of each column. In columns (1) to (6), a patent is the unit of observation, while in columns (7) and (8) firm-year is the unit of observation and the panel is balanced. *Event Year* are dummy variables indicating the relative year around the IPO event (the omitted category is the year of the IPO). Variables are defined in Section I of the Appendix. The estimated model is Ordinary Least Squares (OLS), and standard errors, clustered at the firm level, are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Scaled Citations	Originality	Scaled Originality	Generality	Scaled Generality	Patents	Scaled Patents
Event Year -3	3.086*** (1.035)	0.209 (0.185)	0.014 (0.021)	0.048 (0.039)	0.033** (0.014)	0.053 (0.047)	-0.330 (0.438)	-0.215* (0.113)
Event Year -2	3.752*** (0.843)	0.406*** (0.135)	0.022** (0.011)	0.065*** (0.025)	0.019* (0.010)	0.041 (0.029)	-0.192 (0.345)	-0.141 (0.092)
Event Year -1	1.873*** (0.475)	0.214** (0.089)	0.002 (0.012)	0.006 (0.027)	0.008 (0.008)	0.009 (0.026)	0.022 (0.282)	-0.039 (0.065)
Event Year 1	-2.422*** (0.450)	-0.342*** (0.077)	-0.009 (0.006)	-0.018 (0.016)	-0.007 (0.007)	-0.001 (0.023)	0.069 (0.209)	0.060 (0.062)
Event Year 2	-3.677*** (0.558)	-0.384*** (0.086)	-0.017** (0.007)	-0.046*** (0.018)	-0.015* (0.007)	-0.024 (0.024)	-0.265 (0.428)	-0.049 (0.113)
Event Year 3	-4.748*** (0.635)	-0.597*** (0.094)	-0.017** (0.008)	-0.054*** (0.020)	-0.026*** (0.009)	-0.063** (0.029)	-0.197 (0.468)	-0.049 (0.132)
Event Year 4	-5.739*** (0.789)	-0.662*** (0.110)	-0.022** (0.009)	-0.072*** (0.022)	-0.032*** (0.011)	-0.063* (0.036)	0.091 (0.486)	-0.002 (0.150)
Event Year 5	-6.991*** (0.870)	-0.719*** (0.121)	-0.024** (0.010)	-0.075*** (0.024)	-0.029** (0.013)	-0.046 (0.045)	-0.216 (0.433)	-0.100 (0.152)
Observations	39,306	39,306	38,093	38,093	35,232	35,232	13,302	13,302
R-squared	0.039	0.014	0.010	0.002	0.017	0.002	0.037	0.045
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes

Table A.3 - NASDAQ Returns and Long-run Aggregate Innovation Trends

Table reports the association between long-run innovation trends in the core technologies of IPO filing firms with the two-month post-IPO filing NASDAQ returns. Core technology is a technology class in which a firm's share of patents is above the median in the patent portfolio, in the three years before the IPO filing. Innovation trends in core technologies are calculated using all patents granted by the USPTO in the respective technology classes. The unit of observation is at the level of the firm. Since firms may have multiple core technologies, measures are weighted by the share of patents a firm produced in each core technology class. The dependent variable in column (1) is the change in average patent quality calculated by the average scaled citations of all patents approved in each filer's core technology in the five years after the IPO filing, divided by the average scaled citations in the three years prior to the IPO filing. Similarly, in column (2), the dependent variable is the change in the total number of patents in the core technologies, and in column (3), the dependent variable is the weighted change in the number of patents, when patents are weighted by number of citations. *NASDAQ returns* variable is the two-month NASDAQ returns calculated from the IPO filing date. The estimated model is Ordinary Least Squares (OLS) and robust Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)
Dependent Variable	Patent Novelty	Patent Counts	Weighted Patent Counts
NASDAQ returns	-0.019 (0.064)	-0.051 (0.164)	0.038 (0.195)
Observations	1,079	1,079	1,079
R-squared	0.767	0.261	0.408
Industry FE	yes	yes	yes
Filing Year FE	yes	yes	yes
Control Variables	yes	yes	yes

Table A.4 - Best Patent

Table reports the effect of an IPO on firm’s most cited patent. The dependent variable is the number of scaled citations of the most cited patent applied in the five years after the IPO filing. *IPO* is a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. *NASDAQ returns* variable is the two-month NASDAQ returns calculated from the IPO filing date. Control variables included in regressions are: pre-filing most cited patent, pre-filing average scaled number of patents per year, Pioneer, Early follower, VC-backed variable, and the three-month NASDAQ returns before the IPO filing. All variables are defined in section I of the Appendix. The estimated model is OLS in columns (1) and (2), and two-stage least squares in column (3). Columns (4) estimate the specification using a quasi maximum likelihood Poisson model. In all specifications, marginal effects are reported. *Magnitude* is equal to the ratio of the *IPO* coefficient, divided by the pre-filing scaled number of patents per year. Robust Standard errors are reported in parentheses. In columns (4) standard errors are corrected using the delta method. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Model	OLS	OLS	2SLS - IV	Poisson IV
IPO	0.343 (0.254)		-3.059* (1.706)	-3.551** (1.781)
NASDAQ returns		-1.830* (0.987)		
Magnitude	8.09%		-72.15%	-83.75%
Observations	1079	1079	1079	1079
R-squared	0.259	0.261	0.140	0.174
Filing year FE	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Control Variables	yes	yes	yes	yes

Table A.5 - Citation Rates

Table reports the association of patent citation rates and IPO completion choice. The dependent variable is the number of scaled citations a granted patent receives in a given year. The unit of observation is at the patent-year level. The sample includes all patents granted before the IPO filing year. *IPO* is a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. *Post Filing* is a dummy variable equals to one if a given year is after the IPO filing year. Robust Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Post Filing x IPO	0.077 (0.299)	0.091 (0.298)	0.091 (0.281)	0.067 (0.297)	0.079 (0.296)	0.084 (0.278)
Post Filing	0.341 (0.261)	-0.156 (0.254)	-0.140 (0.238)	0.357 (0.260)	-0.127 (0.244)	-0.138 (0.234)
Observations	11,271	11,271	11,271	11,271	11,271	11,271
R-squared	0.004	0.007	0.010	0.006	0.010	0.013
Firm FE	yes	yes	yes	no	no	no
Patent FE	no	no	no	yes	yes	yes
Patent Age FE	no	yes	yes	no	yes	yes
Citing Year FE	no	no	yes	no	no	yes

Table A.6 - Pre-1999 results

Table reports the effect of an IPO on innovation novelty on firms that filed to go public before 1999. The dependent variable is the average scaled citations in the five years after the IPO filing. *IPO* is a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. *NASDAQ returns* variable is the two-month NASDAQ returns calculated from the IPO filing date. Control variables included in the regressions are: pre-filing average scaled citations, pre-filing average scaled number of patents per year, Pioneer, Early follower, VC-backed dummy, and the three-month NASDAQ returns before the IPO filing. All variables are defined in section I of the Appendix. Sample includes all observations in columns (1) to (3), and only firms that filed to go public before 1999 in columns (4) to (6). *Magnitude* is the ratio of the *IPO* coefficient to the pre-filing average of scaled citations. Robust Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Model	OLS	OLS	2SLS-IV	OLS	OLS	2SLS-IV
Sample	Full	Full	Full	Pre-1999	Pre-1999	Pre-1999
IPO	-0.019 (0.069)		-0.831** (0.409)	0.0610 (0.0820)		-0.924* (0.543)
NASDAQ returns		-0.498** (0.239)			-0.598* (0.360)	
Magnitude	-1.02%	-	-43.51%	3.38%	-	-51.04%
Observations	1079	1079	1079	763	763	763
R-squared	0.239	0.242	0.128	0.199	0.200	0.059
Filing year FE	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes
Control variables	yes	yes	yes	yes	yes	yes

Table A.7 - Second Attempt IPO Filings

Table reports the effect of an IPO on innovation novelty using different specifications of the endogenous variable, exploring the effect of second attempt IPO filings. Columns (1) to (4) illustrate first stage regressions and columns (5) to (8) present instrumental variables results. The dependent variable in column (1) is *IPO*, a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. In columns (2), dependent variables *IPO2* is a dummy variable equals to one if a firm went public in the two years after the IPO filing, regardless of whether it withdrew its filing initially. *IPO3* is the dependent variable for column (3), and is similarly defined for a three-year horizon. In column (4) the dependent variable is *FractionIPO* which is the fraction of IPO years in the five years after the IPO filing. In columns (5) to (8) the dependent variable is the scaled citations in the five years after the IPO filing date. *NASDAQ returns* variable is the two-month NASDAQ returns calculated from the IPO filing date. Control variables included in the regressions are: pre-filing average scaled citations, pre-filing average scaled number of patents per year, Pioneer, Early follower, VC-backed dummy, and the three-month NASDAQ returns before the IPO filing. All variables are defined in section I of the Appendix. In columns (1) to (4) the estimated model is Ordinary Least Squares (OLS), and Two-stage Least Squares (2SLS) in columns (5) to (8). Robust Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	IPO	IPO2	IPO3	FractionIPO	Scaled Citations	Scaled Citations	Scaled Citations	Scaled Citations
	OLS	OLS	OLS	OLS	IV-2SLS	IV-2SLS	IV-2SLS	IV-2SLS
NASDAQ returns	0.598*** (0.126)	0.552*** (0.119)	0.516*** (0.118)	0.532*** (0.113)				
IPO					-0.831** (0.409)			
IPO2						-0.898** (0.446)		
IPO3							-0.960** (0.481)	
FractionIPO								-0.931** (0.465)
Observations	1,079	1,079	1,079	1,079	1,079	1,079	1,079	1,079
R-squared	0.152	0.143	0.142	0.148	0.128	0.123	0.109	0.117
Filing year FE	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes
Control variables	no	no	no	no	no	no	no	no

Table A.8 - Inventor Summary Statistics

Table reports summary statistics of innovative activity of 16,108 inventors with at least a single patent application before and after the IPO filing date. Inventors are classified in three categories. A *stayer* is an inventor with at least a single patent before and a single patent after the IPO filing at the same sample firm. A *leaver* is an inventor with at least a single patent at a sample firm before the IPO filing, and at least a single patent in a different company after the IPO filing. A *newcomer* is an inventor who has at least a single patent after the IPO filing at a sample firm, but no patents before, and has at least a single patent at a different firm before the IPO filing. Panel A compares the innovative activity of inventors of IPO and withdrawn firms. Panel B compares the innovative activity of inventors in firms that experienced a NASDAQ drop versus other filers in the same year. A firm is said to experience a NASDAQ drop if the two-month NASDAQ returns from the date of the IPO filing are within the bottom 25 percent of all filers in the same year. All variables are described in section I of the Appendix. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

Panel A - Complete vs. Withdrawn IPOs

	IPO Firms					Withdrawn Firms				
	count	mean	count	mean	difference	count	mean	count	mean	difference
<i>Pre-IPO Filing:</i>			<i>Leavers</i>	<i>Stayers</i>		<i>Leavers</i>		<i>Stayers</i>		
Scaled Citations	3743	2.37	3806	2.12	0.253***	708	2.36	558	2.74	-0.374**
Scaled Number of Patents	3743	1.1	3806	1.01	0.088***	708	1.21	558	1.29	-0.085
<i>Post-IPO Filing:</i>			<i>Newcomers</i>	<i>Stayers</i>		<i>Newcomers</i>		<i>Stayers</i>		
Scaled Citations	6787	1.62	3806	1.41	0.210***	506	1.4	558	3.11	-1.709***
Scaled Number of Patents	6787	0.86	3806	1.28	-0.423***	506	0.86	558	1.14	-0.274***

Panel B - Reduced Form

	No NASDAQ Drop					NASDAQ Drop				
	count	mean	count	mean	difference	count	mean	count	mean	difference
<i>Pre-IPO Filing:</i>			<i>Leavers</i>	<i>Stayers</i>		<i>Leavers</i>		<i>Stayers</i>		
Scaled Citations	3351	2.38	3370	2.15	0.224***	1100	2.34	994	2.34	0.001
Scaled Number of Patents	3351	1.10	3370	1.05	0.045	1100	1.17	994	1.02	0.146*
<i>Post-IPO Filing:</i>			<i>Newcomers</i>	<i>Stayers</i>		<i>Newcomers</i>		<i>Stayers</i>		
Scaled Citations	5665	1.58	3370	1.58	0.007	1628	1.67	994	1.80	-0.120
Scaled Number of Patents	5665	0.86	3370	1.30	-0.437***	1628	0.84	994	1.13	-0.296***

Table A.9 - Inventor Mobility and Changes in Innovative Productivity

Table reports the effects of an IPO on inventors' mobility and innovative activity. Inventors are classified into three categories, as defined in Table A.8. In columns (1) the sample is restricted to stayers and the dependent variable is the average scaled citations after the IPO filing. In column (2), sample includes in the sample stayers and leavers. The dependent variable is *Late Leavers*, a binary variable that equals one if an inventor patented in a different firm for the first time three years after the IPO filing. Column (3) includes stayers and newcomers. The dependent variable is *Late Newcomers*, a binary variable that equals one if a newcomer produced their first patent in a sample firm at least three years after the IPO filing. In column (4), sample includes stayers and leavers, and the dependent variable is *Spinout1*, which is a binary variable equals to one if an inventor generated a spin-out. A spin-out is an out of sample firm, in which the number of applied patents before the leaver's patent is one. *IPO* is a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. The instrument is the two-month NASDAQ returns calculated from the IPO filing date. In all specifications I control for the average scaled citations and scaled number of patents before the IPO filing of the inventor. Additional control variables are: Pioneer, Early follower, VC-backed variable, and the three-month NASDAQ return before the IPO filing. Variables are described in section I of the Appendix. All models, except column (1), are estimated using two-stage least squares. Column (1) estimates the instrumental variable approach using a quasi maximum likelihood Poisson model. *Magnitude* is equal to the *IPO* coefficient, divided by the pre-filing average scaled citations. Robust Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent variable	Citations of Stayers	Late Leavers	Late Newcomers	Spinout1
Model	Poisson	2SLS - IV	2SLS - IV	2SLS - IV
IPO	-1.169*** (0.397)	0.275*** (0.070)	0.351*** (0.069)	0.102** -0.049
Magnitude	-51.23%	-	-	-
Observations	6657	5678	9334	8773
R-squared	0.121	0.043	0.084	0.035
Filing year FE	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Control Variables	yes	yes	yes	yes

Table A.10 - External Technologies Summary Statistics

Table reports summary statistics of firm acquisitions in the three years before and five years after the IPO filing. Panel A compares IPO firms and withdrawn firms and their respective M&A activity before and after the IPO filing. Panel B details the ownership status of target firms. Panel C describes the summary statistics of acquisitions of targets with patents. Panel D is a simplified reduced form table, illustrating differences in likelihood to acquire external patents between filers that experienced a NASDAQ drop and other filers in the same year. A firm is said to have experienced a NASDAQ drop if the two-month NASDAQ returns after the IPO filing is within the bottom 25 percent of all filers in a given year. Panel E compares internal patents generated by IPO firms after they went public with the external patents they acquired through mergers and acquisitions. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

Panel A - Acquisitions before and after IPO filing

	Complete	Withdrawn	Difference
<u>Three years pre-IPO filing</u>			
Total number of acquisitions	178	46	-
Avg. number of acquisitions per firm	0.12	0.14	-0.022
Likelihood to acquire at least a single firm	0.09	0.10	-0.009
Amount spent on acquisitions	3.94	7.05	-3.113
<u>Five years post-IPO filing</u>			
Total number of acquisitions	4043	428	-
Avg. number of acquisitions per firm	2.27	0.59	1.688***
Likelihood to acquire at least a single firm	0.66	0.24	0.419***
Amount spent on acquisitions	173.47	41.64	131.8***

Panel B - Target ownership status

Ownership Status		
Public	324	7.98%
Public Sub.	604	14.88%
Private Sub.	585	14.41%
Private	2,547	62.73%
Total Public	928	22.86%
Total Private	3,132	77.14%

Panel C - Acquisitions of external patents

Three years pre-IPO filing	Complete	Withdrawn	difference
Avg. number of external patents per firm	0.08	0.14	-0.057
Likelihood to buy an external patent	0.01	0.02	-0.006
Fraction of external patents in portfolio	0.01	0.03	-0.013

Five years post-IPO filing	Complete	Withdrawn	difference
Avg. number of external patents per firm	4.91	0.84	4.066**
Likelihood to buy an external patent	0.16	0.06	0.097***
Fraction of external patents in portfolio	0.31	0.08	0.229***

Panel D - Reduced form

Pre IPO-filing	No NASDAQ Drop	NASDAQ Drop	difference
Number external patents per firm	0.09	0.04	-0.046
Likelihood to buy an external patent	0.01	0.01	-0.000
Fraction of external patents in portfolio	0.02	0.01	-0.004

Post IPO-filing	No NASDAQ Drop	NASDAQ Drop	difference
Number of external patents per firm	4.70	1.27	3.424***
Likelihood to buy an external patent	0.15	0.07	0.083***
Fraction of external patents in portfolio	0.28	0.12	0.153***

Panel E - Comparing external and internal patents of IPO firms

	Internal	External	difference
Citations	7.563	10.709	-3.145***
Scaled citations	1.45	1.65	-0.196**
Core technology	0.659	0.501	0.157***
New technology	0.271	0.456	-0.185***

Table A.11 - Total Innovation - External and Internal Combined

Table reports the effect of an IPO on total innovation novelty, aggregating both internal and external patents. The dependent variable is the average scaled citations of both internal and external patents in the five years after the IPO filing. Internal patent belongs to the post-IPO filing period if it is applied in the five years following the filing. External patent belongs to the post-IPO filing period, if it was acquired in the five years following the filing. *IPO* is a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. *NASDAQ returns* variable is the two-month NASDAQ returns calculated from the IPO filing date. Control variables included in the regressions are: pre-filing average scaled citations of both internal and external patents, pre-filing average scaled number of internal and external patents per year, Pioneer, Early follower, VC-backed dummy, and the three-month NASDAQ returns before the IPO filing. All variables are defined in section I of the Appendix. In columns (1) and (2) the estimated model is Ordinary Least Squares (OLS), and Two-stage Least Squares (2SLS) in column (3). Column (4) estimates the instrumental variables approach using a quasi maximum likelihood Poisson model. In all specifications, marginal effects are reported. *Magnitude* is the ratio of the *IPO* coefficient to the pre-filing average of scaled citations. Robust Standard errors are reported in parentheses. The standard errors in column (4) are corrected using the delta method. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Scaled Citations	Scaled Citations	Scaled Citations	Scaled Citations
Model	OLS	OLS	2SLS-IV	Poisson-IV
IPO	0.044 (0.058)		-0.676** (0.345)	-0.763** (0.345)
NASDAQ returns		-0.402** (0.195)		
Magnitude	2.4%		-37.5%	-42.2%
Observations	1,162	1,162	1,162	1,162
R-squared	0.221	0.223	0.104	0.112
Filing year FE	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Control variables	yes	yes	yes	yes

Table A.12 - Agency Free Benchmark

Table reports the effects of an IPO on firm innovative activity and inventors mobility relative to withdrawn firms that are the least likely to suffer from agency problems. The dependent variables are listed separately in each column. In columns (1)-(2), the unit of observation is at the firm level and the dependent variable is the average scaled citations in the five years after the IPO filing. In columns (3)-(4), the unit of observation is at the individual level, an inventor is included in the sample only if either a *stayer* or *leaver*, and the dependent variable is a dummy indicating whether an individual is a leaver. A *stayer* is an inventor with at least a single patent before and a single patent after the IPO filing at the same sample firm. A *leaver* is an inventor with at least a single patent at a sample firm before the IPO filing, and at least a single patent in a different company after the IPO filing. In the sub-sample *Benchmark*, the sample includes all IPO firms and only withdrawn firms backed by a venture capital firm and managed by a non-founder CEO. The *All* sub-sample includes the all IPO and withdrawn firms. Information about CEO position is collected from initial registration statements which are available from 1996. *IPO* is a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. The instrument is the two-month NASDAQ returns calculated from the IPO filing date. In all specifications I control for the average scaled citations and scaled number of patents before the IPO filing of the inventor. Additional control variables are: Pioneer, Early follower, VC-backed variable, and the three-month NASDAQ return before the IPO filing. Variables are described in section I of the Appendix. All models are estimated using two-stage least squares. Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent Variable	Scaled Citations	Scaled Citations	Leavers	Leavers
Model	2SLS-IV	2SLS-IV	2SLS-IV	2SLS-IV
IPO	-0.895*	-1.554**	0.212***	0.394***
	(0.475)	(0.786)	(0.066)	(0.105)
Sample	All	Benchmark	All	Benchmark
Observations	576	498	5,709	5,090
Filing year FE	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Control variables	yes	yes	yes	yes

Table A.13 - Capital Intensive Commercialization

Table reports the effects of an IPO on innovative activity of various firm subgroups to explore the hypothesis that access to capital and capital intensive commercialization lead firms to reduce innovation quality. The unit of observation is at the firm level and the dependent variable is the average scaled citations in the five years after the IPO filing. The *Small Issuance* sub-sample includes all withdrawn firms, and all IPO firms that have below median proceeds from primary shares issuance (scaled by firm assets). The *Large Firms* sub-sample includes top %25 largest IPO firms, by assets, at the time of the IPO, and all withdrawn firms. The *Cash Rich* sub-sample includes top %25 cash richest firms at the time of the IPO (relative to firm assets) and all withdrawn firms. The *Low Costs* sub-sample includes all firms in industries in which commercialization costs are likely to be low. Such industries include Computers, software and electronic devices. *IPO* is a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. The instrument is the two-month NASDAQ returns calculated from the IPO filing date. In all specifications I control for the average scaled citations and scaled number of patents before the IPO filing of the inventor. Additional control variables are: Pioneer, Early follower, VC-backed variable, and the three-month NASDAQ return before the IPO filing. Variables are described in section I of the Appendix. All models are estimated using two-stage least squares. Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent Variable	Scaled Citations	Scaled Citations	Scaled Citations	Scaled Citations
IPO	-1.003* (0.592)	-0.730* (0.418)	-0.758* (0.426)	-1.249** (0.589)
Sample	Small Issuance	Large Firms	Cash Rich	Low Costs
Observations	464	599	560	682
Filing year FE	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Control variables	yes	yes	yes	yes

Table A.14 - Five-year post-IPO buy-and-hold returns versus various benchmarks

The table reports five-year buy-and-hold abnormal returns on IPOs (both equal-weighted and value-weighted) compared with alternative benchmarks. For each IPO, the returns are calculated by compounding monthly returns. Abnormal return is a simple difference between IPO five-year average return and corresponding benchmark. The sample of IPO firms is split into *High Innovation* and *Low Innovation*. A firm is defined as *High Innovation* if its innovation quality, measured by average scaled citations, in the five years after the IPO is within the top 50%, and *Low Innovation* otherwise. Following Lyon, Barber, and Tsai (1999), t-statistics (reported in parenthesis) are skewness-adjusted to correct for negative bias.

	High innovation		Low Innovation	
	Equal Weighted	Value Weighted	Equal Weighted	Value Weighted
Nasdaq Composite	0.029 (0.96)	0.024 (0.82)	-0.095 (-4.65)	-0.057 (-2.03)
Fama-French Industry Portfolio	0.024 (0.78)	0.016 (0.53)	-0.100 (-4.78)	-0.059 (-2.17)
CRSP Index	0.058 (1.89)	0.012 (0.41)	-0.070 (-3.62)	-0.086 (-2.97)

Table A.15 - Performance Adjusted Market Returns

Table reports risk-adjust market return in the five years following the IPO of publicly traded firms. *RMRF* is the value weighted market return on all NYSE/AMEX/ Nasdaq firms (RM) minus the risk free rate (RF) which is the one-month Treasury bill rate. *SMB* (small minus big) is the difference each month between the return on small firms and big firms. *HML* (high minus low) is the difference each month between the return on a portfolio of high book-to-market stocks and the return on a portfolio of low book-to-market stocks. The sample of IPO firms is split into *High Innovation* and *Low Innovation*. A firm is defined as *High Innovation* if its innovation quality, measured by average scaled citations, in the five years after the IPO is within the top 50%, and *Low Innovation* otherwise. Columns (1) and (3) present results for the CAPM regressions, and columns (2) and (4) report the Fama-French three factor regressions. Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	High	High	Low	Low
	Innovation	Innovation	Innovation	Innovation
Intercepts	0.008*	0.010***	0.002	0.005
	(0.005)	(0.004)	(0.004)	(0.003)
RMRF	1.668***	1.374***	1.448***	1.118***
	(0.098)	(0.083)	(0.093)	(0.073)
SMB		1.238***		1.240***
		(0.116)		(0.103)
HML		-0.489***		-0.620***
		(0.125)		(0.112)
R-squared	0.496	0.683	0.451	0.701

Table A.16 - Innovation Values (Based on Kogan et al. 2012)

The table reports the innovation economic value of patents produced by IPO firms in the five years following the IPO, using the Kogan et al. (2013) measure. A patent innovation value is measured by stock market reaction in the three-day window around the day a patent is issued to the firm. Specifically, Kogan et al. (2012) construct the change in firm value as the return of the firm minus the return of the market portfolio, times the firms market capitalization on the day before the announcement in 1982 US dollars. *Yearly Innovation Value* aggregates the sum of stock market reaction to all patents applied in a given year. In columns (1) to (4), yearly innovation values are reported for the five years post-IPO for all IPO firms in the sample. For a comparison, column (5) is taken from Table 2 of Kogan et al. (2012), reporting yearly innovation values of all public firms in the US from 1926 to 2010. Yearly Innovation Value is scaled by Assets at IPO in column (2), R&D Expenditure in column (3), and market capitalization at the end of the year in columns (4) and (5).

	(1)	(2)	(3)	(4)	(5)
	Yearly Innovation Value (\$M)	Yearly Innovation Value (\$M)	Yearly Innovation Value (\$M)	Yearly Innovation Value (\$M)	Yearly Innovation Value (\$M)
Scaling	-	Assets at IPO	R&D Expenditure	Market Cap	Market Cap
Sample	IPO	IPO	IPO	IPO	Kogan et al. (2012)
Mean	46.056	0.862	2.003	0.085	0.055
50%	3.57	0.068	0.408	0.017	0
75%	14.46	0.253	1.281	0.049	0.014
90%	59.017	0.934	3.657	0.138	0.172
95%	156.549	2.3	6.567	0.254	0.339

Table A.17 - Post-IPO Expenditure of Publicly Traded Firms

The table reports summary statistics of Research and Development Expenditure, Capital Expenditure, and Advertisement in the five years following the IPO of the firms that went public in the sample. In panel B, expenditure is scaled by either *Assets* or *Assets0*. *Assets0* is firm assets at the time of the IPO. *Assets* is firm assets at respective year.

Panel A

Year	R&D (\$M)		CAPEX (\$M)		Advertisement (\$M)	
	Mean	Median	Mean	Median	Mean	Median
0	10.92	4.755	15.57	1.974	8.733	0.822
1	15.32	7.041	21.95	3.188	11.24	1.25
2	20.12	8.506	24.9	3.386	13.42	1.372
3	23.64	9.05	27	3.049	16.17	1.338
4	26.77	9.801	30.45	3.291	20.1	1.3
5	29.58	10.31	35.44	3.577	22.24	1.408

Panel B

Year	R&D	CAPEX	Advertisement	R&D	CAPEX	Advertisement	
	Scaling	Assets0	Assets0	Assets	Assets	Assets	
		Median	Median	Median	Median	Median	
0		10.00%	4.20%	1.70%	10.00%	4.20%	1.70%
1		17.00%	6.80%	2.60%	12.00%	4.90%	1.70%
2		20.00%	7.30%	2.90%	13.00%	4.50%	1.60%
3		21.00%	6.90%	3.00%	13.00%	3.80%	1.50%
4		22.00%	7.20%	2.60%	12.00%	3.60%	1.30%
5		24.00%	7.50%	3.10%	12.00%	3.40%	1.30%

Table A.18 - Use of Proceeds

Table reports the effects of an IPO on inventors mobility and innovative activity. The dependent variables are listed separately in each column. In columns (1)-(2), the unit of observation is at the firm level and the dependent variable is the average scaled citations in the five years after the IPO filing. In columns (3)-(4), the unit of observation is at the individual level, inventors are included in the sample only if they are either a *stayer* or *leaver*, and the dependent variable is a dummy indicating whether an individual is a leaver. A *stayer* is an inventor with at least a single patent before and a single patent after the IPO filing at the same sample firm. A *leaver* is an inventor with at least a single patent at a sample firm before the IPO filing, and at least a single patent in a different company after the IPO filing. In sub-sample *Research Intent*, the sample includes all firms that list technological development in the use of proceeds section the IPO prospectus. Information on use of proceeds is collected from initial registration statements which are available from 1996. *IPO* is a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. The instrument is the two-month NASDAQ returns calculated from the IPO filing date. In all specifications I control for the average scaled citations and scaled number of patents before the IPO filing of the inventor. Additional control variables are: Pioneer, Early follower, VC-backed variable, and the three-month NASDAQ return before the IPO filing. Variables are described in section I of the Appendix. All models are estimated using two-stage least squares. Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent Variable	Scaled Citations	Scaled Citations	Leavers	Leavers
Model	2SLS-IV	2SLS-IV	2SLS-IV	2SLS-IV
IPO	-0.895*	-0.957**	0.212***	0.280***
	(0.475)	(0.476)	(0.066)	(0.085)
Sample	All	Research Intent	All	Research Intent
Observations	576	432	5,709	3,370
Filing year FE	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Control variables	yes	yes	yes	yes

Table A.19 - Managerial Entrenchment

Table reports the effects of an IPO on inventors mobility and innovative activity. The dependent variables are listed separately in each column. In columns (1)-(2), the unit of observation is at the firm level and the dependent variable is the average scaled citations in the five years after the IPO filing. In columns (3)-(4), the unit of observation is at the individual level, inventors are included in the sample only if they are either a *stayer* or *leaver*, and the dependent variable is a dummy indicating whether an individual is a leaver. A *stayer* is an inventor with at least a single patent before and a single patent after the IPO filing at the same sample firm. A *leaver* is an inventor with at least a single patent at a sample firm before the IPO filing, and at least a single patent in a different company after the IPO filing. In sub-sample *Chair*, the sample includes all firms (IPO and withdrawn) that at the time of the IPO filing the CEO acts as the chairman of the board. The *No Chair* sub-sample includes all firms that at the time of the IPO filing the CEO is not the chairman of the board. Information about CEO position is collected from initial registration statements which are available from 1996. *IPO* is a dummy variable equals to one if a firm completed the IPO filing, and zero otherwise. The instrument is the two-month NASDAQ returns calculated from the IPO filing date. In all specifications I control for the average scaled citations and scaled number of patents before the IPO filing of the inventor. Additional control variables are: Pioneer, Early follower, VC-backed variable, and the three-month NASDAQ return before the IPO filing. Variables are described in section I of the Appendix. All models are estimated using two-stage least squares. Standard errors are reported in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent Variable	Scaled Citations	Scaled Citations	Leavers	Leavers
Model	2SLS-IV	2SLS-IV	2SLS-IV	2SLS-IV
IPO	-1.202** (0.588)	-0.338 (0.497)	0.158** (0.068)	-0.119 (0.083)
Sample (CEO Role)	Not Chair	Chair	Not Chair	Chair
Observations	369	266	3,936	2,286
Filing year FE	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Control variables	yes	yes	yes	yes