# Industry Technological Innovations and Initial Public Offerings: An Empirical Analysis

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*This paper examines the effect of industry technological innovations on IPO volume, IPO timing, and post-IPO firm performance. Using three patent-related measures, we find that a higher level of industry technological innovations is followed by more IPOs. This technological innovation effect on IPO volume is more pronounced in more competitive industries. Furthermore, firms that went public in periods of higher industry technological innovations earn greater stock returns, grow faster in sales, capital expenditures and R&D expenditures, and are more likely to survive within three years following their IPOs. These findings are consistent with the view that technological innovations result in improved productivity and investment opportunities and thus encourage firms to go public to finance future investments.*

## INTRODUCTION

This paper examines the effect of industry technological innovations on the initial public offering (IPO) decision of a firm. Technological innovations are one of the main reasons why firms go public. First, technological innovations may cause higher aggregate market returns (Hsu (2009)) and trigger stock market "bubbles" (Pastor and Veronesi (2009)), so firms go public in response to favorable market conditions[2]. Second, technological innovations may indicate greater uncertainties in the product market, so firms go public to gain competitive advantages over industry rivals (Maksimovic and Pichler (2001), Hsu, Reed, and Rocholl (2010), Chod and Lyandres (2011)). Finally, technological innovations may suggest better investment opportunities (Chemmanur and Fulghieri (1999)), so firms go public in order to finance future investments (Lowry (2003)).

Although the literature suggests different reasons why technological innovations may affect IPO activities, little empirically tests whether technological innovations indeed have impacts on IPOs. Using three patent-related measures, this paper fills in the gap by examining whether industry technological innovations affect the IPO volume, the timing of IPO, and post-IPO firm investment and performance. This research further investigates whether the results support one or all of the three aforementioned reasons why industry technological innovations affect IPOs.

We find that the level of technological innovations in an industry has positive and significant effects on the industry IPO volume in the following year during the period of 1975 to 2002; furthermore, such effects are stronger in more competitive industries, consistent with the view that innovations interact with the competitive environment in the going public decision (Maksimovic and Pichler (2001), Spiegel and Tookes (2009)). Finally, the level of industry technological innovations significantly affects the timing of IPO: Firms are more likely to go public in periods of higher industry technological innovations. These

results are robust to controlling for potential confounders including industry characteristics and aggregate stock market conditions.

We then consider two hypotheses—the market timing hypothesis and the investment opportunity hypothesis—that explain why industry technological innovations affect subsequent IPO volume. These two hypotheses also shed light on how technological innovations affect post-IPO firm investments and performance. The market timing hypothesis posits that periods of high technological innovations reflect stock market overvaluation or investor sentiment (Rossi (2006)). Thus, firms time IPOs and go public to take advantage of the "window of opportunities" (Ritter, 1991). Alternatively, the investment opportunity hypothesis suggests that periods of high technological innovations reflect improved productivity and investment opportunities, so firms go public in need of capital to fund future investments (Lowry (2003)).

Since both the market timing and the investment opportunity hypothesis predict a higher subsequent IPO volume following greater industry technological innovations, to distinguish between these hypotheses, we implement the empirical testing strategy used in Pagano et al. (1998) by examining the ex-post evidence. A positive effect of technological innovations on post-IPO firm investments and performance supports the investment opportunity hypothesis, whereas a negative effect suggests the market timing hypothesis. We find that firms that go public during periods of more technological innovations earn higher stock returns, grow faster in sales, capital expenditures and R&D investments, and are more likely to survive after their IPOs. The findings thus support the investment opportunity hypothesis.

This paper thus offers several key contributions. First, using patent-related measures, this paper identifies industry technological innovations as an important determinant of IPO volume, the timing of IPOs, and post-IPO firm investment and performance. Second, this paper sheds light on the literature that examines the link between a firm's equity issuance decision and investment. In particular, the present study finds a condition under which equity issuances are associated with greater subsequent investments: periods of greater industry technological innovations. The findings are consistent with the investment purposes of the going public decision (Lowry (2003), Pastor and Veronesi (2005), Dittmar and Thakor (2007)).

Finally, this study extends the industrial organization literature linking innovations, product market competition, and firm investments. In Schumpeter's early work in 1912, he focused on the "creative destruction" story in competitive industries, in which innovations may create greater (rational or irrational) expectations on industry valuations and cause excessive entries and investments. This view is also discussed in Reiganum (1989) and Hoberg and Phillips (2009). The present study shows that technological innovations cause more firms to go public in more competitive industries, but no evidence of excessive investments is found, since greater technological innovations are associated with better firm performance and a higher chance of survival after IPOs.

The remainder of this paper is organized as follows: Section I reviews related literature. Section II develops the hypotheses for empirical tests. Section III describes the data, sample, and the main variables. Section IV discusses the empirical findings. Section V performs further robustness checks. Section VI concludes the paper.

## LITERATURE REVIEW

The present study is related to theoretical and empirical literature that links technological innovations to the corporate financing decisions. Maksimovic and Pichler (2001) are among the first that examine the role of technological innovations in IPOs in a theoretical framework. They argue that the decision and the timing of IPOs depend on both the displacement risk borne by technological innovations and the new entry risk. Spiegel and Tookes (2008) develop a model that considers the interaction among innovation, competition, and financing decisions. They find that the private versus public financing decisions depend mainly on the magnitude of the technological improvement.

For related empirical literature, Rossi (2006) finds that (1) industry patents are associated with higher levels of subsequent seasoned equity issuance and reduced leverage (2) Industry patenting is associated

with negative subsequent stock returns and (3) equity issuers do not increase investment, dividends and acquisitions. He therefore concludes that patents are catalysts of investor sentiment. In contrast, this study finds a positive and significant industry patenting effect on post-IPO stock and operating performance, investment and survival of firms, and thus provides a different perspective from Rossi (2006).

## HYPOTHESES DEVELOPMENT

In this section, we discuss the following two hypotheses that explain the potential technological innovations effect on IPO volume, IPO timing, and post-IPO firm investment and performance.

### Market Timing Hypothesis

Technological innovations may create favorable stock market conditions so firms may go public to take advantage on the overvalued market conditions (Ritter (1991), Lerner (1994), Pagano et al. (1998), Baker and Wurgler (2000)). Hsu (2009) finds that technological shocks are indeed associated with greater aggregate market risk premiums. Further, Pastor and Veronesi (2009) find that stock prices exhibit "bubbles" during technological revolutions. These empirical findings provide the "market timing" foundation of how technological innovations may affect the IPO decision. In a related study, Pastor and Veronesi (2005) develop a theory of rational IPO waves, in which higher prior uncertainties borne by innovations cause greater IPO volume.

If, indeed, technological innovations support the market timing story, we should expect technological innovations to have a positive effect on IPO volume but a negative impact on post-IPO firm investment, survival, and performance.

> *Hypothesis 1 (Market timing): The level of industry technological innovations has a positive impact on subsequent IPO volume, but a negative effect on the stock returns, operating performance, investments and survival probabilities of firms following their IPOs.*

### Investment Opportunity Hypothesis

Technological innovations may also indicate improved productivity and more investment opportunities, so firms go public to raise funds for future investments in response to better product market conditions. Chemmanur and Fulghieir (1999) predict that positive productivity shocks reduce the information production costs of going public and thus triggers more firms to go public. Lowry (2003) finds a higher IPO volume in expansion periods during which demands for capital are higher. Finally, Chemmanur, Nandy, and He (2007) find that the IPO decision is triggered by industry total factor productivity (TFP).

In contrast to the market timing hypothesis, if technological innovations represent increasing industry productivity, we still expect industry technological innovations to positively affect IPO volume, but have a positive impact on post-IPO firm investment, survival, and performance.

> *Hypothesis 2 (Investment Opportunity): The level of industry technological innovations has a positive impact on subsequent IPO volume, as well as post-IPO stock returns, operating performance, investments and survival probabilities.*

## DATA AND VARIABLES

### Description of Sample

The sample of IPOs comes from Jay Ritter's web site (http://bear.cba.ufl.edu/ritter/). This IPO sample comprises 6,162 nonfinancial firms that went public from 1975 to 2002 and excludes best efforts offers, ADRs, closed-end funds, REITs, banks and savings and loans (S&Ls), partnerships, firms not covered by CRSP within six months of the offering, and IPOs with an offer price below $5.00 per share. The

accounting information for IPO firms comes from Compustat. To examine the survival of firms after IPO, we obtain firms' delisting information, including the date of and reasons for delisting, from CRSP.

Data on industry characteristics variables come from two main sources. First, industry patenting data come from the NBER Patent Citation Database (for details about this database, see Hall, Jaffe, and Tratjenberg (2001)). This data provide detailed information on the identity, the application and the grant date of patent recipient. Second, other industry characteristics variables are constructed using the Compustat data. Finally, the founding dates of the sample IPO firms also come from Jay Ritter's website (See Appendix A of Loughran and Ritter (2004) for a detail description).

**Description of Variables**

*Industry Technological Innovations*

The main research question is whether industry technological innovations affect IPO volume and post-IPO firm performance. In measuring technological innovations, patents are typically used in the literature as they are considered the realizations of R&D and innovative outputs.[3] We therefore use the following procedure to construct the industry technological innovations measures. First, following Hou and Robinson (2006), we use the three-digit standard industrial classification (SIC) codes as the industry definition for the IPO sample. Second, from the NBER Patent Citation Database, we obtain the annual patent counts of a given three-digit SIC industry from 1963 to 2002, and then take the natural log of annual patent counts (in hundreds) in a given three-digit SIC industry as a measure of industry technological innovations.

In addition to simple patent counts, we also consider the number of citations each patent receives, because Aghion et al. (2005) and Hall, Jaffe, and Tratjenberg (2005) indicate that patent citations provide a good measure of the value of innovations. We thus construct two additional measures of industry technological innovations that are based on the annual citation-weighted patents, as described in detail in the Appendix.

*Other Industry Characteristics and Aggregate Market Conditions*

Other industry characteristics, which are also documented to affect the IPO decision, include industry valuations (Pagano et al. (1998)), industry capital intensity (Chemmanur and Fulghieri (1999), the degree of difficulty in project evaluation (Chemmanur and Fulghieri (1999)), the stage of the industry in its life cycle (Ritter and Welch (2002)), and the degree of product market competition (Maksimovic and Pichler (2001)).

In this paper, we use the median market-to-book ratio of the three-digit SIC industry to proxy for industry valuations and the industry median ratio of capital expenditures to assets as a proxy for industry capital intensity. To measure the difficulty of project evaluation, we use the industry median ratio of research expenses to assets, since investment projects in more research-intensive industries are more difficult to evaluate. We use the industry median returns on assets (ROA) as a proxy for the stage of the industry's life cycle, since more mature industries tend to have higher levels of ROAs. Finally, we use the Herfindahl index to measure the degree of industry competition.

In addition to industry characteristics, aggregate market conditions also have substantial effects on the IPO volume. Lowry (2003) and Pastor and Veronesi (2005) show that IPO volume is positively related to the level of the stock market returns. Pastor and Veronesi (2005) also find that aggregate market returns volatility, a proxy for equity premium, has substantial effects on IPO volume. In this paper, we use the annual CRSP value-weighted returns (compounded by monthly CRSP value-weighted returns) as a proxy for aggregate market returns. We also follow Pastor and Veronesi (2005) and calculate the change in annul market volatility, where the market volatility is computed as the standard deviation of monthly CRSP VW returns within the year.

*Summary Statistics*

Table I reports the summary statistics of 6,162 sample IPO firms by IPO year. First, IPO volume fluctuated substantially over time, consistent with observations by Ritter and Welch (2002), Lowry

(2003), among others. In contrast to IPO volume, the distribution of firm age at IPO seems to be relatively stable over time, except for a drop in the bubble period and a later rebound after bubble period. The pre-IPO firm size, as proxied by firm sales one year before IPOs, is relatively stable over time, except for a sudden jump after the bubble period (from 118.87 million dollars in 2000 to 1836.71 million dollars in 2001), possibly due to the burst of the internet bubble.

Table I also reports the time distribution of pre-IPO industry patents, as measure by the total number of granted patents in an IPO firm's industry one year before IPO. Industry patent counts increased slowly before 1995, and grew drastically after then. The other two citation-weighted patents measures also show similar patterns.

Overall, table I suggests substantial fluctuations of IPO volume and increasing trend for industry technological innovations over time. Therefore, we thus include the year fixed-effects in the all of following multivariate analyses.

## EMPIRICAL FINDINGS

In this section, we first present evidence that industry technological innovations affect IPO volume and that such technological innovation effects depend on the degree of industry competition. We then report the effect of industry technological innovations on the stock returns, operating performance, investment and survival of firms following their IPOs.

### Industry Technological Innovations and IPO Volume

Table II reports the main results—panel regressions of the effect of industry technological innovations on annual IPO volume. According to Lowry (2003), IPO volume is highly persistent and nonstationary over time. To address the problem of nonstationary IPO volume, we follow Lowry (2003) and Pastor and Veronesi (2005) by deflating the number of IPOs by the total number of listed firms obtained in CRSP at the end of the previous year. Thus, in Table II, the dependent variable *Number of IPOs in the 3-digit SIC industry* refers to the number of IPOs adjusted by CRSP-listed firms.

In models (1) to (3), we present the baseline regressions of three industry patenting measures on industry IPO volume in the subsequent year. After controlling for industry and year fixed-effects, all three measures of technological innovations have positive and significant effects on the subsequent industry IPO volume. This finding provides the first evidence that technological innovations indeed affect subsequent IPO volume.

The technological innovations effect on IPO volume reported in models (1) to (3) could be confounded by other industry characteristics. Therefore, we include five industry characteristics variables: industry concentration ratio (Herfindahl index), industry capital intensity, industry ROA, industry market-to-book ratio, and industry research intensity. Models (4) to (6) (Table II) show that the results don't materially change after controlling for other industry characteristics.

Finally, according to Hsu (2009), technological innovations are associated with higher aggregate market risk premiums. Lowry (2003) and Pastor and Veronesi (2005) show that aggregate market returns and risk premiums have significant effects on IPO volume. In model (7) to (9) of Table II, we further control for annual CRSP value-weighted returns and volatilities as measures of aggregate market returns and risk premium. The coefficients of the three industry patenting measures remain positive and significant. In summary, the results presented in Table II suggest that technological innovations positively affect subsequent IPO volume in the industry, and such technological innovation effects do not appear to be driven by other industry factors and aggregate stock market conditions.

### Industry Competition, Technological Innovations, and IPO Volume

The previous subsection provides evidence that industry technological innovations indeed significantly affect the subsequent IPO volume. A natural follow-up question is whether the technological innovation effects on IPO volume vary across industries, and if so, what factors determine the cross-sectional difference of the technological innovation effect.

The degree of industry competition may be one such factor. Competitive industries may bear greater risk from new competition borne by innovations (see Hoberg and Phillips (2009) for detailed discussions). So when rapid technological changes take place, firms in more competitive industries are more likely to stay private due to concerns of revealing key information to potential rivals (Campbell (1979)). Alternatively, technological innovation may force firms in more competitive industries to go public in order to gain competitive advantages over competitors (Chod and Lyandres (2011), Hsu, Reed, and Rocholl (2010)). Indeed, public financing brings publicity, reduce leverage and provides cheaper capital than private equities (Ritter and Welch (2002), Chemmanur and Fulghieri (1999), Michelacci and Suarez (2004)). These are all important aspects of a firm's competitiveness when facing changing competitive environments.

In this subsection, we investigate whether the technological innovations effect on IPO volume depends on degree of industry competition. Table III reports the regressions results. In the regressions, we include industry patenting, Herfindahl index, and the interaction term of both variables. In models (1) to (3), the three measures of industry technological innovations still have positive and significant effects on the industry IPO volume. Negative coefficients on Herfindahl index suggests more IPOs take place in more competitive industry, though the coefficients are insignificant. Most interestingly, the interaction term of each of the three industry patenting variables and the Herfindahl index become negative and statistically significant at the one percent level. This finding shows that technological innovations induce more IPOs in more competitive industries and thus provide the following two implications. First, the finding is consistent with the view that innovations interact with the competitive environment in the going public decision. Second, the result seems to support the "competitive advantage" view that firms in more competitive industries go public during periods of high technological innovations to pre-empt industry competitors.

**Industry Innovations and the Timing of IPOs**

In this section, we investigate whether industry technological innovations affect the timing of IPOs. The previous two sections provide evidence that technological innovations trigger a higher subsequent IPO volume in the industry. Consistent with these findings, industry technological innovations may result in a shorter time-to-IPO. Researchers ordinarily employ a hazard model to deal with duration data,[4] specifying the hazard function and conditioning it on particular explanatory variables. In the context of this paper, a firm has a certain probability of going public at a given point in time, so the hazard rate is the conditional probability that the firm will go public between time $t$ and $\Delta t$, divided by the probability that the firm hasn't gone public before $t$. We use the Cox proportional hazard model, which accommodates time-varying explanatory variables in the survival regressions. The accommodation of time-varying explanatory variables is crucial in this analysis, as it captures the dynamic effect of industry technological effects on the timing of IPOs.

Table IV presents results from the Cox proportional hazard regressions of firm age at IPO on three measures of industry technological innovations and other control variables. A positive coefficient on $x$ suggests that an increase in $x$ results in a higher hazard rate—here, a higher probability of going public and a shorter expected time-to-IPO. From Models (1) to Model (3), the positive and significant coefficients for all three measures suggest that firms are more likely to go public (or have short time-to-IPO) when the industry experiences higher levels of technological innovations. The results are still robust after we control for other industry characteristics variables (Models (4) to Model (6)) and aggregate markets conditions (Models (7) to Model (9)). This result is thus consistent with previous findings that industry technological innovations have positive impacts on subsequent IPO volume.

In addition to industry technological innovations, consistent with the findings in Table II and in Table III, firms in more competitive industries have shorter time-to-IPO than firms in more concentrated industries, though the results are not statistically significant in some models. Furthermore, consistent with Chemmanur and Fulghieri (1999) and Chemmanur, He and Nandy (2008), the time-to-IPO decreases with increases in *industry capital intensity*. The time-to-IPO increases with *industry ROA*, suggesting that firms in more mature industries are less likely to go public.

Finally, time-to-IPO significantly decreases with increases in *industry M/B ratio* and *VW Market Returns*; that is, firms are more likely go public in favorable markets conditions (Lerner (1994), Pagano et al. (1998)).

**Industry Technological Innovations and Post-IPO Firm Investment and Performance**

Previous findings describe that industry-level technological innovations significantly explain IPO volume and the timing of IPOs. These findings support the view that technological innovations are one of the main determinants of the going public decision. In this section we examine the effects of industry technological innovations on post-IPO performance, investments and survival for the sample of 6,162 IPO firms. We describe the effect of industry technological innovations on post-IPO stock returns in subsection D1. Subsection D2 reports the industry technological innovations effect on post-IPO operating performance, investment, and survival.

*Post-IPO Stock Returns*

To investigate how (pre-IPO) industry technological innovations affect the post-IPO stock returns, we implement the following panel data regressions model:

$$\mathrm{Ret}_{i,t} = a_0 + a_1 OwnPatents_i + a_2 IndustryPatents_i + a_3 IndustryM/B_i + OtherControls_{i,t-1} + \mu_i + \varepsilon_{i,t} \quad (1)$$

where $\mathrm{Ret}_{i,t}$ is the post-IPO annual returns for firm *i* at year *t*; $OwnPatents_i$ is a dummy variable equal to 1 if the firm earned patents before it went public, and zero otherwise; $IndustryPatents_i$ are the logs of the three aforementioned industry patenting measures in the year before IPO; $IndustryM/B_i$ is the industry market-to-book ratio in the year before IPO; $OtherControls_{i,t-1}$ include the log of firm age, the log of firm asset, CRSP value-weighted market returns and the number of IPOs for firm *i* at year $t-1$, where *t* ranges from the IPO year to three years after the IPO.

The panel regression framework offers the two advantages over cross-sectional regressions. First, panel regressions allow us to examine the effects of pre-IPO firm-specific variables, such as $OwnPatents_i$ and $IndustryPatents_i$, on post-IPO stock returns $\mathrm{Ret}_{i,t}$ while controlling for the dynamic relationship between $OtherControls_{i,t-1}$ and $\mathrm{Ret}_{i,t}$. In this framework, pre-IPO industry technological innovations are considered as observable industry effects. Furthermore, panel regressions also allow us to control for unobserved cross-sectional and time-series dependence.

Table V reports the results. The dependent variables include three measures: raw annual stock returns, annual abnormal returns with CRSP value-weighted returns as the benchmark, and abnormal returns with CRSP equally-weighted returns as the benchmark. These annual stock return variables range from one to three years after IPO. All three industry patenting measures have positive and significant effects on the three post-IPO stock returns measures after controlling for industry and year fixed-effects. The results are also robust to controlling for potential confounders, including *Own Patents before IPO*, *Industry M/B Ratio*, CRSP value-weighted market returns, and the number of IPOs in the previous year.

Overall, the findings provide evidence that firms going public in periods of higher industry technological innovations earn higher stock returns from the IPO year to three years after IPOs.

*Post-IPO Operating Performance, Investment, and Survival*

The previous findings in subsection D1 seem to suggest that industry technological innovations support the investment opportunity hypotheses as outlined in section II. If, indeed, firms choose to go public when the industry faces increasing investment opportunities, we should also observe positive operating performance and investment after IPOs. We thus examine the effect of industry technological

innovations on the post-IPO firm operating performance, investment and survival; we use the same panel regressions framework as mentioned in subsection D1.

Table VI reports the results. Following Campello (2003), we use annual sales growth (the log of annual sales minus the log of annual sales in the previous year) from the IPO year to three years after IPO as a measure of operating performance. From model (1) to (3), after control for industry and year fixed-effects and other control variables, the positive and significant coefficients on three pre-IPO industry patenting measures (0.114, 2.903, and 0.799, respectively) suggest that firms going public in periods with higher technological innovations have higher post-IPO sales growth.

We further examine the investment of firms following their IPOs. The dependent variables in models (4) to (6) (models (7) to (9)) of Table VI are the log of annual capital expenditures (R&D expenditures) minus the log of annual capital expenditures (R&D expenditures) in the previous year. Results from models (4) to (6) suggest that three pre-IPO industry patenting measure still have positive and significant impacts on the post-IPO capital expenditure growth; results from model (7) to (9) also show the same positive effects on the post-IPO R&D expenditures.

Finally, we investigate whether the pre-IPO industry technological innovations affect firms' survival probabilities following their IPOs. In models (9) to (12) (Table VI), the dependent variable is a post-IPO survival dummy equal to 1 if the firm is not delisted in the observation year for reasons other than mergers and acquisitions, and zero otherwise. Industry technological innovations still have positive and significant effects on the post-IPO firms' survival probabilities after controlling for other firm, industry, and aggregate market characteristics.

Other pre-IPO firm and industry characteristics seem to affect post-IPO firm performance, investment and survival as well. For example, consistent with Cockburn and Wagner (2007), firms that own patents before IPO are more likely to survive after IPO, though the coefficients are not statistically significant. Further, consistent with Spence (1977)'s life cycles story, older firms (firms with higher *Log(Age)*) are associated with less sales, capital and R&D expenditure growth.

Overall, Table VI provides further evidence that supports the investment opportunities hypothesis: Firms going public when industries show higher technological innovations perform better, invest more, and are more likely to survive.

## ROBUSTNESS TESTS

The findings described in section IV support the view that technological innovations in the industry level are one of the main determinants of IPO volume. One potential empirical concern is whether the effect of technological innovations on subsequent IPO volume is subject to industry classifications, though the three-digit SIC codes are widely used in the literature as the industry classifications (See Hou and Robinson (2006) and Maksimovic and Phillips (2008), among others). Since the main focus of this study is to investigate the effects of industry-level innovations on IPOs, it is necessary to investigate whether such effects are robust to different industry classifications.

In Table VII, we re-estimate the panel regressions of industry technological innovations on IPO volume in the subsequent year, and the industry is defined as the four-digit SIC codes. Consistent with the results reported in Table II, three industry patenting measures still positively affect the subsequent IPO volume in the same four-digit SIC industry after controlling for other (four-digit SIC) industry characteristics, aggregate market conditions, and industry as well as year fixed-effects. Therefore, the effect of technological innovations on IPO volume is robust to finer industry classifications.

## CONCLUSION

In this paper, we empirically examine the effect of industry technological innovations on subsequent IPO volume, IPO timing, and post-IPO firm investment and performance. Using three patent-related measures, we find that industry technological innovations positively affect subsequent IPO volume. Furthermore, the technological innovation effect on IPO volume is stronger in more competitive

industries, a finding consistent with the view that innovations interact with the competitive environment in the going public decision. Finally, firms are more likely to go public in periods of greater industry technological innovations.

We further study the effect of industry technological innovations on the performance and investment of firms following their IPOs. Firms going public in periods of higher industry technological innovations earn greater stock returns. They also grow faster in sales, capital expenditures and R&D expenditures, and they are more likely to survive within three years after IPOs. These findings support the investment opportunities hypothesis, in which firms go public in response to increasing productivity and investment opportunities caused by industry technological innovations.

This paper sheds light on the product market aspects of the going public decision by outlining the importance of technological innovations on the volume and valuations of IPO firms in the industry level. Nevertheless, the extent to which technological innovations explain existing issues on equity issuance is still unclear. For example, can technological innovations explain the cross-sectional differences of the well documented phenomena, such IPO underpricing and the long-run underperformance? These questions require further research investigation.

## ENDNOTES

1. Hsu is with University of Wisconsin Milwaukee. Email: hsuh@uwm.edu. The author thanks comments from Brian Daugherty, James Huang, Yong-Cheol Kim, Dick Marcus, Merih Sevilir, Ehsan Soofi, and seminar participants at the University of Wisconsin Milwaukee. All remaining errors are my own.
2. For the evidence of how market timing affects the IPO decision, see Ritter (1991), Lerner (1994), and Pagano et al. (1998).
3. For further discussions, see Hall, Jaffe, and Tratjenberg (2001), Kortum and Lerner (2000), Hall, Jaffe, and Tratjenberg (2005), and Lerner, Sorenson, and Stromberg (2011).
4. The duration model appears extensively in the literature; see Chemmanur, He and Nandy (2008).

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## APPENDIX

### THE CONSTRUCTION OF CITATION-WEIGHTED PATENT MEASURES

In this paper, we use two citation-weighted patent measures, following Aghion et al. (2005) and Atanassov, Nanda, and Seru (2007): (1) the citation-weighted patent in which the weight is equal to the number of citations received by the patent, divided by the number of citations received by all patents in a given year, and (2) the citation-weighted patent in which the weight is equal to the number of citations received by the patent, divided by the total number of citations received by all patent within a technology class in a given year, where the technology classes are defined by the U.S. Patent and Trademark Office. Using these two measures, we construct the measures of industry technological innovations using the log of annual total citation-weighted patent counts in a three-digit-SIC industry.

## TABLE I
## SUMMARY STATISTICS

This table reports the summary statistics of 6,162 IPO firms that went public from 1975 to 2002. Averaged values for the following variables are obtained across all firms that went public in a giver year. *Pre-IPO sales* are the book value of firm sales in the year before IPO, measured in 2003 dollars. *Pre-IPO industry patents* are the annual patent counts in the three-digit SIC industry in the year before IPO. *Pre-IPO industry citation-weighted patents (by Year)* are the annual citation-weighted patents in the three-digit SIC industry in the year before IPO, and the weight is the number of citations received by a patent divided by the total number of citations received by all patents in a given year. Pre-IPO industry citation-weighted patents (by tech. category) are the annual citation-weighted patents in the three-digit SIC industry in the year before IPO, and the weight is the number of citations received by a patent divided by the total number of citations received by all patents within a technology class in a given year.

| IPO Year | IPO Volume | Average Firm Age at IPO (Years) | Average Pre-IPO Sales (in millions) | Average Pre-IPO Industry Patents | Average Pre-IPO Industry Citation-weighted Patents (by Year) | Average Pre-IPO Industry Citation-weighted Patents (by Tech. Category) |
|---|---|---|---|---|---|---|
| 1975 | 10 | 48.10 | - | 128.4 | 0.002 | 0.008 |
| 1976 | 25 | 20.64 | 173.88 | 498.48 | 0.008 | 0.056 |
| 1977 | 20 | 7.8 | 21.50 | 319.55 | 0.006 | 0.037 |
| 1978 | 27 | 16.41 | 160.85 | 442.26 | 0.009 | 0.058 |
| 1979 | 40 | 11.25 | 81.91 | 367.08 | 0.007 | 0.054 |
| 1980 | 58 | 9.16 | 108.30 | 308.93 | 0.009 | 0.063 |
| 1981 | 161 | 12.34 | 55.39 | 369.46 | 0.008 | 0.059 |
| 1982 | 61 | 9.77 | 55.810 | 439.89 | 0.009 | 0.070 |
| 1983 | 374 | 10.83 | 78.93 | 424.52 | 0.011 | 0.073 |
| 1984 | 172 | 12.01 | 103.17 | 347.06 | 0.009 | 0.059 |
| 1985 | 195 | 14.52 | 78.27 | 344.12 | 0.007 | 0.048 |
| 1986 | 355 | 14.54 | 111.84 | 357.16 | 0.007 | 0.047 |
| 1987 | 285 | 13.41 | 200.34 | 369.72 | 0.008 | 0.049 |
| 1988 | 121 | 14.36 | 179.99 | 508.74 | 0.009 | 0.056 |
| 1989 | 125 | 10.35 | 209.55 | 577.17 | 0.010 | 0.059 |
| 1990 | 119 | 14.52 | 326.44 | 568.90 | 0.009 | 0.055 |
| 1991 | 260 | 17.29 | 241.76 | 493.36 | 0.009 | 0.053 |
| 1992 | 358 | 18.50 | 194.520 | 588.17 | 0.010 | 0.059 |
| 1993 | 463 | 13.97 | 149.360 | 632.6 | 0.010 | 0.057 |
| 1994 | 402 | 12.68 | 153.240 | 668.96 | 0.011 | 0.060 |
| 1995 | 435 | 10.39 | 177.370 | 1088.4 | 0.018 | 0.094 |
| 1996 | 555 | 12.58 | 199.900 | 1067.33 | 0.018 | 0.090 |
| 1997 | 399 | 14.17 | 164.120 | 1228.7 | 0.019 | 0.087 |
| 1998 | 244 | 12.98 | 204.740 | 1514.6 | 0.023 | 0.105 |
| 1999 | 419 | 8.64 | 286.340 | 3397.99 | 0.040 | 0.162 |
| 2000 | 346 | 9.86 | 118.870 | 3505.11 | 0.037 | 0.161 |
| 2001 | 74 | 19.02 | 1836.710 | 2193.31 | 0.021 | 0.099 |
| 2002 | 59 | 21.39 | 848.930 | 2190.75 | 0.019 | 0.087 |
| 1975-2002 | 6162 | 13.07 | 204.330 | 1075.04 | 0.016 | 0.080 |

## TABLE II
## INDUSTRY TECHNOLOGICAL INNOVATIONS AND IPO VOLUME: PANEL REGRESSIONS

This table reports the panel regressions of three industry patenting measures and other control variables on the IPO volume in the subsequent year. Industries are defined based on the three-digit SIC codes. The dependent variable is the ratio of annual industry IPO volume divided by the total number of CRSP listed firms at the end of the previous year. *Industry Patents* is the log of annual industry patent counts (in hundreds). *Industry Citation Weighted Patent by Year* is the log of annual industry citation-weighted patents, and the weight is the number of citations received by a patent divided by the total number of citations received by all patents in a given year. *Industry Citation Weighted Patent by Tech. Category* is the annual industry citation-weighted patents, and the weight is the number of citations received by a patent divided by the total number of citations received by all patent within a technology class in a given year. *Lag(Number of IPOs)* is the lagged value of the dependent variable in the previous year. *Herfindahl Index* is the concentration ratio of firms' three-digit SIC industry. *Industry Capital Intensity* is the median ratio of capital expenditures to total assets in the industry. *Industry ROA* is the median return on assets in the industry. *Industry M/B ratio* is the median market-to-book ratio of firms' industry. *Industry Research Intensity* is the median R&D expenditures over sales in the industry. *VW Market Returns* are CRSP monthly value-weighted market returns, compounding to annual frequency. *VW Market Volatility* is computed as change in annul market volatility, where the market volatility is computed as the standard deviation of monthly CRSP VW returns within the year. T statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

| Dependent Variable: | *Number of IPOs in the 3-digit SIC Industry* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| *Industry Patents* | 0.082*** | | | 0.060*** | | | 0.047** | | |
| | (8.37) | | | (2.77) | | | (2.36) | | |
| *Industry Citation Weighted Patent by Year* | | 12.463*** | | | 10.006*** | | | 9.743*** | |
| | | (12.65) | | | (6.77) | | | (6.56) | |
| *Industry Citation Weighted Patent by Tech.Catgory* | | | 2.708*** | | | 1.942*** | | | 1.863*** |
| | | | (12.59) | | | (5.13) | | | (4.95) |
| *Lag (Number of IPOs)* | 0.568*** | 0.544*** | 0.552*** | 0.527*** | 0.509*** | 0.521*** | 0.531*** | 0.513*** | 0.524*** |
| | (69.58) | (63.82) | (66.54) | (50.79) | (47.53) | (50.00) | (51.81) | (48.47) | (50.90) |
| *HH* | | | | -0.112*** | -0.108*** | -0.113*** | -0.109*** | -0.107*** | -0.112*** |
| | | | | (-3.28) | (-3.18) | (-3.31) | (3.20) | (-3.14) | (-3.27) |
| *Industry Capital Intensity* | | | | -0.141 | -0.114 | -0.130 | -0.162 | -0.151 | -0.168 |
| | | | | (-0.83) | (-0.67) | (-0.76) | (-0.99) | (-0.93) | (-1.03) |
| *Industry ROA* | | | | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | | | | (-0.15) | (-0.14) | (-0.15) | (0.13) | (0.14) | (0.14) |
| *Industry M/B Ratio* | | | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | | | (0.12) | (0.12) | (0.12) | (0.34) | (0.34) | (0.34) |
| *Industry Research Intensity* | | | | 0.002 | 0.002 | 0.002 | 0.004 | 0.004 | 0.004 |
| | | | | (0.17) | (0.16) | (0.18) | (0.36) | (0.35) | (0.36) |
| *VW Market Returns* | | | | | | | 0.194*** | 0.193*** | 0.191*** |
| | | | | | | | (7.74) | (7.72) | (7.61) |
| *VW Market Volitility* | | | | | | | 0.758*** | 0.740*** | 0.739*** |
| | | | | | | | (3.47) | (3.40) | (3.40) |
| *Constant* | -0.027 | 0.004 | 0.006 | 0.099 | 0.096 | 0.102 | 0.051 | 0.057 | 0.058 |
| | (-0.56) | (0.09) | (0.14) | (0.38) | (0.37) | (0.39) | (0.81) | (0.90) | (0.91) |
| *Industry Fixed-effect* | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year Fixed-effect* | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No |
| *N* | 10668 | 10668 | 10668 | 7223 | 7223 | 7223 | 7223 | 7223 | 7223 |
| *R-Square* | 0.5509 | 0.5548 | 0.5547 | 0.5728 | 0.5575 | 0.5562 | 0.5405 | 0.5430 | 0.5418 |

## TABLE III
## INDUSTRY TECHNOLOGICAL INNOVATIONS, INDUSTRY COMPETITION, AND THE IPO VOLUME

This table reports the panel regressions of three industry patenting measures, *Herfindhal Index*, and the interactions of both industry patenting measures and *Herfindhal Index* on the IPO volume in the subsequent year. Industries are defined based on the three-digit SIC codes. The dependent variable is the ratio of annual industry IPO volume divided by the total number of CRSP listed firms at the end of the previous year. *Industry Patents* is the log of annual industry patent counts (in hundreds). *Industry Citation Weighted Patent by Year* is the log of annual industry citation-weighted patents, and the weight is the number of citations received by a patent divided by the total number of citations received by all patents in a given year. *Industry Citation Weighted Patent by Tech. Category* is the annual industry citation-weighted patents, and the weight is the number of citations received by a patent divided by the total number of citations received by all patent within a technology class in a given year. *Lag(Number of IPOs)* is the lagged value of the dependent variable in the previous year. *Herfindahl Index* is the concentration ratio of firms' three-digit SIC industry. *Industry Capital Intensity* is the median ratio of capital expenditures to total assets in the industry. *Industry ROA* is the median return on assets in the industry. *Industry M/B ratio* is the median market-to-book ratio of firms' industry. *Industry Research Intensity* is the median R&D expenditures over sales in the industry. *VW Market Returns* are CRSP monthly value-weighted market returns, compounding to annual frequency. *VW Market Volatility* is computed as change in annul market volatility, where the market volatility is computed as the standard deviation of monthly CRSP VW returns within the year. T statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

| Dependent Variable: | *IPO Volume in the 3-digit SIC Industry* | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Industry Patents* | 0.160*** | | | 0.150*** | | |
| | (6.56) | | | (6.49) | | |
| *Industry Citation Weighted Patent by Year* | | 17.746*** | | | 17.495*** | |
| | | (10.46) | | | (10.20) | |
| *Industry Citation Weighted Patent by Tech.Catgory* | | | 5.043*** | | | 5.033*** |
| | | | (11.92) | | | (11.84) |
| *Industry Patents* HH* | -0.537*** | | | -0.536*** | | |
| | (-8.75) | | | (-8.62) | | |
| *Industry Citation Weighted Patent by Year*HH* | | -97.722*** | | | -95.313*** | |
| | | (-9.13) | | | (-8.90) | |
| *Industry Citation Weighted Patent by Tech.Catgory*HH* | | | -24.644*** | | | -24.422*** |
| | | | (-15.43) | | | (-15.19) |
| *Lag (Number of IPOs)* | 0.499*** | 0.478*** | 0.445*** | 0.504*** | 0.483*** | 0.451*** |
| | (46.21) | (42.73) | (39.24) | (47.21) | (43.63) | (40.14) |
| *HH* | -0.013 | -0.055 | -0.024 | -0.012 | -0.052 | -0.021 |
| | (-0.37) | (-1.60) | (-0.71) | (-0.32) | (-1.51) | (-0.62) |
| *Industry Capital Intensity* | -0.086 | -0.062 | -0.024 | -0.119 | -0.086 | -0.047 |
| | (-0.51) | (-0.36) | (-0.14) | (-0.73) | (-0.53) | (-0.30) |
| *Industry ROA* | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | (-0.15) | (-0.15) | (-0.14) | (0.13) | (0.13) | (0.14) |
| *Industry M/B Ratio* | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.05) | (0.10) | (0.10) | (0.27) | (0.30) | (0.29) |
| *Industry Research Intensity* | 0.002 | 0.002 | 0.002 | 0.004 | 0.004 | 0.004 |
| | (0.13) | (0.16) | (0.15) | (0.32) | (0.33) | (0.32) |
| *VW Market Returns* | | | | 0.197*** | 0.202*** | 0.204*** |
| | | | | (7.87) | (8.11) | (8.28) |
| *VW Market Volitility* | | | | 0.744*** | 0.740*** | 0.734*** |
| | | | | (3.43) | (3.42) | (3.43) |
| *Constant* | 0.043 | 0.060 | 0.037 | 0.024 | 0.039 | 0.030 |
| | (0.17) | (0.23) | (0.14) | (0.38) | (0.63) | (0.48) |
| *Industry Fixed-effect* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year Fixed-effect* | Yes | Yes | Yes | No | No | No |
| *N* | 7223 | 7223 | 7223 | 7223 | 7223 | 7223 |
| *R-Square* | 0.5598 | 0.5626 | 0.5709 | 0.5453 | 0.5480 | 0.5564 |

## TABLE IV
## INDUSTRY TECHNOLOGICAL INNOVATIONS AND THE TIMING OF IPOS

In this table I provide estimates from a Cox proportional-hazard regression of three industry patenting and other explanatory variables on the firm age at IPO. The dependent variable is firm age at IPO, measured in years. Industries are defined based on the three-digit SIC codes. *Industry Patents* is the log of annual industry patent counts (in hundreds). *Industry Citation Weighted Patent by Year* is the log of annual industry citation-weighted patents, and the weight is the number of citations received by a patent divided by the total number of citations received by all patents in a given year. *Industry Citation Weighted Patent by Tech. Category* is the annual industry citation-weighted patents, and the weight is the number of citations received by a patent divided by the total number of citations received by all patent within a technology class in a given year. *Lag(Number of IPOs)* is the lagged value of the dependent variable in the previous year. *Herfindahl Index* is the concentration ratio of firms' three-digit SIC industry. *Industry Capital Intensity* is the median ratio of capital expenditures to total assets in the industry. *Industry ROA* is the median return on assets in the industry. *Industry M/B ratio* is the median market-to-book ratio of firms' industry. *Industry Research Intensity* is the median R&D expenditures over sales in the industry. *VW Market Returns* are CRSP monthly value-weighted market returns, compounding to annual frequency. *VW Market Volatility* is computed as change in annul market volatility, where the market volatility is computed as the standard deviation of monthly CRSP VW returns within the year. Chi-square statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

| Dependent Variable: | *Firm Age at IPO* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| *Industry Patents* | 0.128*** | | | 0.067*** | | | 0.067*** | | |
| | (207.50) | | | (38.52) | | | (38.34) | | |
| *Industry Citation Weighted Patent by Year* | | 6.849*** | | | 3.630*** | | | 3.608*** | |
| | | (170.57) | | | (36.90) | | | (36.18) | |
| *Industry Citation Weighted Patent by Tech.Catgory* | | | 1.860*** | | | 1.128*** | | | 1.123*** |
| | | | (208.10) | | | (57.19) | | | (56.27) |
| *Lag (Number of IPOs)* | 0.000*** | 0.000** | 0.000** | 0.000*** | 0.000*** | 0.000** | 0.000** | 0.000*** | 0.000** |
| | (8.82) | (6.10) | (5.38) | (7.61) | (6.70) | (6.05) | (5.11) | (4.58) | (4.00) |
| *HH* | | | | -0.167 | -0.205* | -0.182* | -0.163 | -0.203* | -0.180* |
| | | | | (2.35) | (3.63) | (2.88) | (2.25) | (3.57) | (2.81) |
| *Industry Capital Intensity* | | | | 2.614*** | 2.599*** | 2.663*** | 2.661*** | 2.642*** | 2.706*** |
| | | | | (62.16) | (61.42) | (64.08) | (64.13) | (63.25) | (65.91) |
| *Industry ROA* | | | | -1.556*** | -1.666*** | -1.610*** | -1.634*** | -1.741*** | -1.686*** |
| | | | | (70.30) | (90.42) | (81.88) | (74.28) | (94.26) | (85.47) |
| *Industry M/B Ratio* | | | | 0.074*** | 0.074*** | 0.070*** | 0.067*** | 0.068*** | 0.064*** |
| | | | | (32.84) | (33.80) | (28.37) | (23.06) | (24.18) | (19.87) |
| *Industry Research Intensity* | | | | 0.085 | 0.118** | 0.103* | 0.081 | 0.116** | 0.100 |
| | | | | (1.60) | (4.63) | (2.90) | (1.42) | (4.28) | (2.65) |
| *VW Market Returns* | | | | | | | 0.206** | 0.191* | 0.194** |
| | | | | | | | (4.40) | (3.77) | (3.89) |
| *VW Market Volitility* | | | | | | | -0.500 | -0.559 | -0.485 |
| | | | | | | | (0.48) | (0.60) | (0.45) |
| *N* | 6115 | 6115 | 5951 | 5951 | 5951 | 5951 | 5951 | 5951 | 5951 |

## TABLE V
## INDUSTRY TECHNOLOGICAL INNOVATIONS AND POST-IPO STOCK PERFORMANCE

This table reports the panel regressions of three industry patenting measures and other control variables on three measures of post-IPO stock returns. Industries are defined based on the three-digit SIC codes. The dependent variable in model (1) to (3) is annual raw returns (compounded by monthly raw returns). The dependent variable in model (4) to (6) is annual abnormal returns (compounded by monthly abnormal returns) with CRSP value-weighted returns as the market benchmark. The dependent variable in model (7) to (9) is annual abnormal returns (compounded by monthly abnormal returns) with CRSP equally-weighted returns as the market benchmark. *Industry Patents* is the log of annual industry patent counts in the year before IPO (in hundreds). *Industry Citation Weighted Patent by Year* is the log of annual industry citation-weighted patents in the year before IPO, and the weight is the number of citations received by a patent divided by the total number of citations received by all patents in a given year. *Industry Citation Weighted Patent by Tech. Category* is the annual industry citation-weighted patents in the year before IPO, and the weight is the number of citations received by a patent divided by the total number of citations received by all patent within a technology class in a given year. *Own Patents before IPO* is a dummy variable equal to 1 if the firm earned patents before it went public, and 0 otherwise. *Industry M/B ratio* is the median market-to-book ratio of firms' industry in the year before IPO. *Log(Age)* is the log of firm age from founding to the observation year. Log(Asset) is the log of the book value of firm asset in the previous year. *VW Market Returns* are CRSP monthly value-weighted market returns, compounding to annual frequency. *Number of IPOs* is the total number IPO volume in the previous year. T statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

| Dependent Variable: | *Annual Returns* | | | *Annual Abnormal Returns (VW)* | | | *Annual Post-IPO Returns (EW)* | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| *Industry Patents* | 0.045** | | | 0.040** | | | 0.051*** | | |
| | (2.03) | | | (2.04) | | | (2.67) | | |
| *Industry Citation Weighted Patent by Year* | | 1.569** | | | 1.437** | | | 1.645** | |
| | | (1.96) | | | (2.02) | | | (2.38) | |
| *Industry Citation Weighted Patent by Tech.Catgory* | | | 0.639** | | | 0.625** | | | 0.699*** |
| | | | (2.29) | | | (2.52) | | | (2.90) |
| *Own Patents before IPO* | 0.006 | 0.007 | 0.006 | 0.016 | 0.017 | 0.016 | 0.019 | 0.020 | 0.019 |
| | (0.33) | (0.38) | (0.35) | (0.97) | (1.03) | (1.00) | (1.18) | (1.25) | (1.21) |
| *Industry M/B Ratio* | -0.059*** | -0.058*** | -0.058*** | -0.063*** | -0.063*** | -0.064*** | -0.061*** | -0.059*** | -0.059*** |
| | (-3.40) | (-3.37) | (-3.41) | (-4.13) | (-4.11) | (-4.20) | (-4.02) | (-3.93) | (-4.00) |
| *Log(Age)* | 0.026*** | 0.026*** | 0.026*** | 0.023*** | 0.023*** | 0.023*** | 0.021*** | 0.021*** | 0.021*** |
| | (3.03) | (3.02) | (3.01) | (3.02) | (3.01) | (2.99) | (2.89) | (2.87) | (2.86) |
| *Log(Asset)* | 0.000 | 0.000 | 0.000 | -0.005 | -0.005 | -0.005 | -0.005 | -0.005 | -0.005 |
| | (0.04) | (0.03) | (0.04) | (-1.10) | (-1.10) | (-1.09) | (-1.19) | (-1.21) | (-1.20) |
| *VW Market Returns* | 0.229*** | 0.229*** | 0.229*** | 0.204*** | 0.204*** | 0.205*** | 0.167*** | 0.167*** | 0.167*** |
| | (4.21) | (4.21) | (4.22) | (4.23) | (4.23) | (4.24) | (3.55) | (3.53) | (3.55) |
| *Number of IPOs* | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** |
| | (3.28) | (3.26) | (3.19) | (4.19) | (4.18) | (4.12) | (3.95) | (3.91) | (3.83) |
| *Constant* | 0.185 | 0.195 | 0.198 | 0.213 | 0.223 | 0.007 | -0.032 | -0.022 | -0.018 |
| | (0.93) | (0.97) | (0.99) | (1.20) | (1.25) | (1.28) | (-0.19) | (-0.13) | (-0.10) |
| *Industry Fixed-effect* | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year Fixed-effect* | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *N* | 21434 | 21434 | 21434 | 21434 | 21434 | 21434 | 21434 | 21434 | 21434 |
| $R^2$ | 0.0504 | 0.0504 | 0.0505 | 0.0302 | 0.0302 | 0.0303 | 0.0208 | 0.0207 | 0.0208 |

## TABLE VI
## INDUSTRY TECHNOLOGICAL INNOVATIONS AND POST-IPO FIRM INVESTMENT AND OPERATING PERFORMANCE

This table reports the panel regressions of three industry patenting measures and other control variables on measures of post-IPO firm investment, operating performance, and survival. Industries are defined based on the three-digit SIC codes. The dependent variable in model (1) to (3) is the log of annual sales minus the log of annual sales in the previous year. The dependent variable in model (4) to (6) is the log of annual capital expenditures minus the log of annual capital expenditures in the previous year. The dependent variable in model (7) to (9) is the log of annual R&D expenditures minus the log of R&D expenditures in the previous year. The dependent variable in model (10) to (12) (Probit regressions) is a dummy variable equal to 1 if the firm is not delisted in the observation year for reasons other than mergers and acquisitions, and zero otherwise. *Industry Patents* is the log of annual industry patent counts in the year before IPO (in hundreds). *Industry Citation Weighted Patent by Year* is the log of annual industry citation-weighted patents in the year before IPO, and the weight is the number of citations received by a patent divided by the total number of citations received by all patents in a given year. *Industry Citation Weighted Patent by Tech. Category* is the annual industry citation-weighted patents in the year before IPO, and the weight is the number of citations received by a patent divided by the total number of citations received by all patent within a technology class in a given year. *Own Patents before IPO* is a dummy variable equal to 1 if the firm earned patents before it went public, and 0 otherwise. *Industry M/B ratio* is the median market-to-book ratio of firms' industry in the year before IPO. *Log(Age)* is the log of firm age from founding to the observation year. Log(Asset) is the log of the book value of firm asset in the previous year. Log(Capex) is the log of firm capital expenditures in the previous year. *Number of IPOs* is the total number IPO volume in the previous year. T statistics are reported in parentheses from model (1) to (9). Z statistics are reported in parentheses from model (10) to (12). ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

| Dependent Variable: | *Sales Growth* | | | *Capex Growth* | | | *R&D Growth* | | | *Post-IPOSurvival* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| *Industry Patents* | 0.114*** | | | 0.162*** | | | 0.140*** | | | 0.153*** | | |
| | (7.46) | | | (6.54) | | | (6.39) | | | (3.06) | | |
| *Industry Citation Weighted Patent by Year* | | 2.903*** | | | 3.911*** | | | 2.130*** | | | 3.699** | |
| | | (5.27) | | | (4.40) | | | (3.25) | | | (2.05) | |
| *Industry Citation Weighted Patent by Tech.Catgory* | | | 0.799*** | | | 1.135*** | | | 0.608*** | | | 1.280** |
| | | | (4.18) | | | (3.68) | | | (2.70) | | | (1.96) |
| *Own Patents Before IPO* | 0.016 | 0.018 | 0.017 | 0.045** | 0.049** | 0.048** | -0.004 | -0.002 | -0.002 | 0.052 | 0.057 | 0.056 |
| | (1.25) | (1.42) | (1.39) | (2.25) | (2.43) | (2.38) | (-0.31) | (-0.13) | (-0.17) | (1.16) | (1.26) | (1.24) |
| *Industry M/B Ratio* | 0.009 | 0.017 | 0.023* | -0.033* | -0.020 | -0.013 | 0.005 | 0.018 | 0.023 | -0.041 | -0.029 | -0.025 |
| | (0.72) | (1.41) | (1.95) | (-1.72) | (-1.05) | (-0.68) | (0.33) | (1.15) | (1.47) | (-1.12) | (-0.79) | (-0.70) |
| *Log(Age)* | -0.129*** | -0.130*** | -0.130*** | -0.078*** | -0.078*** | -0.079*** | -0.093*** | -0.095*** | -0.096*** | -0.008 | -0.009 | -0.010 |
| | (-22.13) | (-22.20) | (-22.27) | (-8.23) | (-8.31) | (-8.36) | (-10.04) | (-10.21) | (-10.26) | (-0.40) | (-0.46) | (-0.48) |
| *Log(Asset)* | -0.058*** | -0.059*** | -0.059*** | 0.347*** | 0.346*** | 0.346*** | 0.002 | -0.000 | -0.000 | 0.019 | 0.019 | 0.019 |
| | (-10.52) | (-10.60) | (-10.63) | (39.16) | (39.06) | (39.03) | (0.20) | (-0.05) | (-0.06) | (1.02) | (1.02) | (1.01) |
| *Log(Capex)* | 0.019*** | 0.019*** | 0.019*** | -0.427*** | -0.427*** | -0.427*** | 0.001 | 0.001 | 0.000 | 0.022 | 0.022 | 0.022 |
| | (4.19) | (4.16) | (4.14) | (-59.51) | (-59.50) | (-59.50) | (0.10) | (0.10) | (0.06) | (1.49) | (1.48) | (1.48) |
| *Number of IPOs* | -0.000*** | -0.000*** | -0.000*** | -0.000 | -0.000 | -0.000 | -0.000* | -0.000** | -0.000** | 0.000 | 0.000 | 0.000 |
| | (-7.30) | (-7.52) | (-7.80) | (-0.29) | (-0.50) | (-0.72) | (-1.79) | (-2.15) | (-2.38) | (1.18) | (1.05) | (0.97) |
| *Constant* | 0.984*** | 0.100*** | 0.995*** | -0.092 | -0.070 | -0.074 | -0.043 | -0.027 | -0.026 | 1.219*** | 1.279*** | 1.282*** |
| | (5.28) | (5.37) | (5.34) | (-0.30) | (-0.23) | (-0.25) | (-0.23) | (-0.14) | (-0.14) | (2.87) | (3.02) | (3.02) |
| *Industry Fixed-effect* | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year Fixed-effect* | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *N* | 19460 | 19460 | 19460 | 19695 | 19695 | 19695 | 10106 | 10106 | 10106 | 20419 | 20419 | 20419 |
| $R^2$ | 0.0988 | 0.0974 | 0.0970 | 0.2149 | 0.2139 | 0.2137 | 0.0935 | 0.0907 | 0.0904 | 0.0696 | 0.0690 | 0.0690 |

## TABLE VII
## INDUSTRY TECHNOLOGICAL INNOVATIONS AND THE IPO VOLUME USING FOUR-DIGIT SIC INDUSTRIES

This table reports the panel regressions of three industry patenting measures and other control variables on the IPO volume in the subsequent year. Industries are defined based on the four-digit SIC codes. The dependent variable is the ratio of annual industry IPO volume by the total number of CRSP listed firms at the end of the previous year. *Industry Patents* is the log of annual industry patent counts (in hundreds). *Industry Citation Weighted Patent by Year* is the log of annual industry citation-weighted patents, and the weight is the number of citations received by a patent divided by the total number of citations received by all patents in a given year. *Industry Citation Weighted Patent by Tech. Category* is the annual industry citation-weighted patents, and the weight is the number of citations received by a patent divided by the total number of citations received by all patent within a technology class in a given year. *Lag(Number of IPOs)* is the lagged value of the dependent variable in the previous year. *Herfindahl Index* is the concentration ratio of firms' three-digit SIC industry. *Industry Capital Intensity* is the median ratio of capital expenditures to total assets in the industry. *Industry ROA* is the median return on assets in the industry. *Industry M/B ratio* is the median market-to-book ratio of firms' industry. *Industry Research Intensity* is the median R&D expenditures over sales in the industry. *VW Market Returns* are CRSP monthly value-weighted market returns, compounding to annual frequency. *VW Market Volatility* is computed as change in annul market volatility, where the market volatility is computed as the standard deviation of monthly CRSP VW returns within the year. T statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

| Dependent Variable: | *Number of IPO in the 4-digit SIC Industry* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| *Industry Patents* | 0.030*** | | | 0.023** | | | 0.018* | | |
| | (6.18) | | | (2.35) | | | (1.91) | | |
| *Industry Citation Weighted Patent by Year* | | 6.193*** | | | 5.540*** | | | 5.329*** | |
| | | (8.83) | | | (5.27) | | | (5.02) | |
| *Industry Citation Weighted Patent by Tech.Catgory* | | | 1.114*** | | | 0.777*** | | | 0.734*** |
| | | | (7.72) | | | (3.20) | | | (3.01) |
| *Lag (Number of IPOs)* | 0.530*** | 0.524*** | 0.529*** | 0.482*** | 0.477*** | 0.482*** | 0.489*** | 0.484*** | 0.489*** |
| | (80.37) | (79.02) | (80.37) | (56.40) | (55.58) | (56.74) | (57.93) | (57.07) | (58.20) |
| *Herfindhal Index* | | | | -0.060*** | -0.058*** | -0.060*** | -0.061*** | -0.059*** | -0.061*** |
| | | | | (-4.38) | (-4.26) | (-4.37) | (-4.38) | (-4.27) | (-4.38) |
| *Industry Capital Intensity* | | | | -0.079 | -0.074 | -0.079 | -0.084 | -0.083 | -0.089 |
| | | | | (-1.15) | (-1.07) | (-1.15) | (-1.26) | (-1.25) | (-1.35) |
| *Industry ROA* | | | | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | | | | (-0.02) | (-0.01) | (-0.02) | (0.30) | (0.31) | (0.31) |
| *Industry M/B Ratio* | | | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | | | (0.29) | (0.29) | (0.28) | (0.55) | (0.56) | (0.56) |
| *Industry Research Intensity* | | | | -0.000 | -0.000 | -0.000 | 0.001 | 0.001 | 0.001 |
| | | | | (-0.02) | (-0.02) | (-0.02) | (0.35) | (0.35) | (0.35) |
| *VW Market Returns* | | | | | | | 0.124*** | 0.123*** | 0.123*** |
| | | | | | | | (10.74) | (10.66) | (10.61) |
| *VW Market Volitility* | | | | | | | 0.462*** | 0.455*** | 0.456*** |
| | | | | | | | (4.60) | (4.54) | (4.55) |
| *Constant* | -0.004 | -0.003 | -0.003 | 0.029 | 0.029 | 0.028 | 0.047 | 0.049 | 0.049 |
| | (-0.13) | (-0.12) | (-0.11) | (0.72) | (0.74) | (0.70) | (1.31) | (1.36) | (1.37) |
| *Industry Fixed-effect* | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year Fixed-effect* | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No |
| *N* | 17254 | 17254 | 17254 | 11206 | 11206 | 11206 | 11206 | 11206 | 11206 |
| *R-Square* | 0.4818 | 0.4830 | 0.4824 | 0.4888 | 0.4899 | 0.4891 | 0.4668 | 0.4679 | 0.4671 |