Regulatory Relief, Product Life Cycle, and Innovation Performance of IPO Firms: Evidence from the JOBS Act

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ABSTRACT

Early-stage firms, whose products are primarily in the nascent stages of the product innovation lifecycle, differ significantly from mature-stage firms in their innovation strategies and financial resources. This study investigates how firms at varying stages of the product life cycle respond to regulatory reforms designed to lower the costs of going public. Exploiting the 2012 Jumpstart Our Business Startups (JOBS) Act as a quasi-natural experiment and employing a difference-in-differences framework, the paper provides novel evidence that a firm's product life cycle stage critically influences its innovation trajectory following regulatory relief. Early-stage newly public firms experienced increased access to capital and R&D spending but produced fewer patents of lower technological quality and market value compared to mature-stage firms. Mature-stage firms, in contrast, translated the regulatory changes into significant improvements in both innovation output and quality. Additionally, early-stage post-JOBS firms acquired fewer external innovations and faced higher failure rates than their mature counterparts. These findings underscore the importance of considering product life cycle dynamics in designing policies aimed at fostering innovation and ensuring the viability of newly public firms. The results also offer important insights into the ongoing discourse on promoting a vibrant IPO market and the role of tailored regulatory approaches.

Keywords: Innovation; Patents; IPO; Product Life Cycle; Regulation; JOBS Act

1. Introduction

Technological innovation is a cornerstone of firm competitive advantage and performance (Baumol, 2002). However, financing innovation - particularly for firms in the early stages of the product life cycle- poses significant challenges due to inherent uncertainty and information asymmetry (Kerr and Nanda, 2015). Public equity markets have historically served as a critical source of capital for innovative entrepreneurial firms, which represent a substantial share of initial public offerings (IPOs) (Brown et al. 2009). While going public can provide access to much-needed capital, it also imposes increasingly stringent disclosure and governance requirements, potentially diverting scarce resources away from innovation activities. The 2011 IPO Task Force Report directly attributed the decade-long decline in U.S. IPO activity to a “cascading” regulatory burden.

In response to these concerns, the U.S. Congress enacted the Jumpstart Our Business Startups (JOBS) Act in April 2012, introducing significant regulatory relief measures aimed at lowering the costs of going public and incentivizing innovation among emerging growth firms. Widely regarded as a landmark reform in securities regulation, the JOBS Act has generated significant scholarly interest, with prior studies focusing predominantly on IPO activity and associated costs (Dambra et al. 2015; Barth et al. 2017). However, the Act’s broader economic implications, particularly its impact on the innovation outcomes of newly public firms, remain underexplored.

This study addresses this gap by examining the JOBS Act's effects on going public firms' innovation outcomes, using patent-based metrics to capture the quantity, technological quality, and private value of innovation. Understanding these effects is critical, as emerging firms disproportionately contribute to major inventions and employment growth (Akcigit and Kerr 2018; Haltiwanger et al. 2013).

We study patents because a vast literature has established that patented inventions represent the most credible evidence of the quality and extent of firm innovation (e.g., Griliches 1990; Hall et al. 2005; Somaya, 2012). Consequently, patents play an important role in a firm's access to external capital and market valuation (Graham and Hegde, 2015; Kogan et al. 2017). Prior research highlights that small, innovative firms derive substantial value from patents due to limited alternatives for protecting their ideas (Farre-Mensa et al. 2020; Stoffman et al. 2022).

Drawing on frameworks from the literature on product life cycles, innovation, and agency costs, this study posits that the Act's impact on innovation depends on a firm's position within the product life cycle. Early-stage firms, whose products are primarily in the exploratory and development stage, differ significantly from mature-stage firms in terms of financial resources and strategic priorities (e.g., Abernathy and Utterback, 1978; Klepper, 1996). Since early-stage firms depend heavily on external financing, it is reasonable to expect these firms to benefit the most from the JOBS Act in terms of the relative amount of capital raised and subsequent spending on R&D. However, increased R&D investment by early-stage firms may not necessarily produce more and better innovation outcomes. Early-stage firms tend to focus on exploratory innovation aimed at creating novel products (Akcigit and Kerr, 2018)[1]. These innovations are inherently more uncertain with high failure rates (Levinthal and March, 1993). Moreover, the transition from private to public ownership can impose an important set of agency costs that may stifle innovation (Bernstein, 2015). The immediate infusion of cash from an IPO can also lead managers to undertake excessively risky projects or to continue investing in projects that do not meet investor standards (Sahlman, 1990; Hertzel et al. 2012).

[1] In contrast, mature-stage firms tend to focus on exploitative innovation which aims at achieving incremental improvements of existing products.

In sum, we predict substantial heterogeneity in the innovation consequences of the JOBS Act. Specifically, while early-stage firms going public after the Act may experience increased R&D spending, they might ultimately produce fewer and less technologically and economically valuable innovations, compared to their mature-stage counterparts.

We employ a generalized difference-in-differences framework, exploiting the JOBS Act's enactment as a natural experiment. We compare innovation outcomes for relief-eligible issuers before and after the Act, with a second margin of comparison based on firms' exposure to the earliest stage of the product life cycle (continuous treatment). That exposure is defined as the proportion of firm products in the early development stage. We classify the life cycle stage of firm products using the newly developed text-based approach from Hoberg and Maksimovic (2022).

Our sample comprises 746 innovative IPOs between 2003 and 2018, during which we observe a marked increase in the relative number of early-stage issuers following the Act. Before delving into the main analysis, we validate the differential effect of the product life cycle measure on key IPO outcomes, namely, the amount of capital raised and subsequent R&D expenditures. Results indicate that the JOBS Act significantly benefited early-stage firms compared to mature-stage firms, enabling them to raise more capital, which they then appear to direct toward R&D. This finding aligns with the Act's stated objective of facilitating capital raising for emerging innovative firms. We therefore next ask whether these firms successfully converted increased R&D spending into tangible (patented) innovation outputs.

We find that, when not considering the product life cycle, the Act is positively associated with post-IPO innovation performance. On average, post-JOBS issuers generated 24% more patents during the first two post-IPO years than their pre-JOBS peers. However, this effect varies significantly based on firms' exposure to the earliest product life cycle stage. Early-stage firms going public after the Act produce significantly fewer patents relative to mature-

stage firms. Specifically, a post-JOBS issuer at the mean of the early product stage distribution produces 24% fewer patents than a post-JOBS mature-stage IPO with no early-stage products. Difference-in-differences estimates and parallel trend analyses confirm that this differential impact is driven by early-stage firms going public after the Act's passage, with no observable pretreatment trends.

To explore whether these outcomes reflect a strategic shift rather than a decline in innovativeness (intensive margin), we examine whether post-JOBS early-stage firms potentially produced patents of greater technological quality and higher economic value. We measure a patent's technological quality using forward citations, breakthrough patent counts, and its scope, and we measure a patent's economic value using the value it creates for firm shareholders. The results do not support this alternative explanation as we find a significant decline in both technological quality and market value of patents produced by post-JOBS early-stage firms compared to mature-stage firms.

We also investigate whether firms compensate for reduced internal innovation by acquiring external innovations through mergers and acquisitions. The findings indicate otherwise: early-stage post-JOBS firms acquired fewer external patents, while mature-stage firms increased their acquisitions of external innovations during the same period.

Finally, we assessed whether the observed differential impact of the Act on innovation outcomes also influences IPO failures (our proxy for poor performance). The results indeed reveal that, on average, early-stage post-JOBS IPOs face significantly higher rates of exchange delisting due to poor performance within three and five years of going public compared to mature-stage counterparts.

Taken together, these findings underscore the critical role of the product life cycle in determining IPO firms' responsiveness to the JOBS Act's regulatory relief. While mature-stage firms effectively leveraged reduced regulatory burdens to enhance innovation output,

early-stage firms failed to convert additional capital and R&D investments into meaningful innovation outcomes. This diminished innovation performance among post-JOBS early-stage firms corresponded with higher failure rates, suggesting that easing regulatory constraints alone is insufficient to foster innovation and long-term viability across all firm types.

This study contributes to the growing literature on the relationship between going public and firm innovation. Prior research has largely documented that newly public firms experience a decline in the quality of their innovations (as measured with patent citations). Bernstein (2015) provides causal evidence of significant declines in patent citations after going public. Aggarwal and Hsu (2014) and Larrain et al. (2024) reported similar patterns in U.S. biotechnology firms and European IPOs, respectively. Wu et al. (2024) highlight that firms with stronger artificial intelligence analytics capabilities experience smaller declines in innovation quality. Studies comparing publicly traded firms with privately held firms (e.g., Gao et al. 2018; Wies and Moorman 2015) document a negative relationship between public status and the technological novelty of innovations with the notable exception of industries highly dependent on external finance (Acharya and Xu 2017). Our paper extends this literature by providing novel evidence on the effects of regulatory reform - specifically, the JOBS Act - on post-IPO innovation. Importantly, we identify the product life cycle stage as a critical determinant of how firms respond to regulatory changes, highlighting that mature firms benefit more from reduced regulatory burdens than early-stage counterparts.

This paper also contributes to the literature examining the influence of regulations, particularly the JOBS Act, on IPO activity and post-IPO investment decisions. Barth et al. (2017), Dambra et al. (2015), and Chaplinsky et al. (2017) study how the JOBS Act impacted private firms' decisions to go public and the associated costs. In a related paper, Dambra and Gustafson (2021) examined the Act's impact on capital expenditures and R&D spending, comparing firms around the public float-based regulatory threshold. Our study adds to this

body of work by providing new evidence on the JOBS Act's impact on innovation output and how it varies with the firm exposure to the life cycle stages of their products. Crucially, while we document that early-stage firms going public after the Act raised more capital in their IPO and increased R&D investment (which is in line with previous findings), our findings indicate that early-stage firms were less successful in translating increased capital infusion and R&D into more numerous or higher-quality tangible (patented) innovations.

The findings of this paper also speak to the broader literature on the relationship between regulatory environments and corporate innovation as well as the emerging literature in economics and finance on the importance and effects of product life cycles. Recent studies by Aghion et al. (2023) and Park et al. (2024) have explored the effects of labor regulations in France and U.S. federal regulations, respectively, on corporate innovation. In an important paper, Hoberg and Maksimovic (2022) develop the text-based product life cycle stage measures for Compustat firms and study their implications for investment. Using accounting (cash flow) based measure of firm lifecycle, Allen et al. (2021) show that younger firms are more vulnerable to costs of increased regulatory burden. In contrast, our analysis leverages a unique policy experiment that eased the regulatory burden on going public firms to demonstrate how such reforms differentially affect innovation among emerging growth firms at different stages of their product life cycle.

Our findings also offer important policy implications for regulators and lawmakers. Regulators could consider balancing the benefits of reduced regulatory compliance costs with the potential risks posed to early-stage firms, which may not effectively convert these freed-up resources into innovation. Lawmakers could account for the importance of distinct stages of stages of firms' product life cycles when designing new securities legislation, such as the currently debated in the U.S. Congress "H.R. 2793, The Encouraging Public Offerings Act".

2. Background, Analytical Framework, and Hypotheses

To address the decade-long decline in the number of IPOs, particularly among emerging firms, the IPO Task Force was established in March 2011 to propose policy measures aimed at reversing that trend. In October 2011, the Task Force presented a report attributing the decline in IPO activity primarily to the increased regulatory burden, which significantly raised the costs of going public without proportionately enhancing the benefits of being a public company. To mitigate these challenges, the report recommended a series of reforms to reduce disclosure, governance, and compliance requirements during the IPO process, enabling potential issuers to raise capital more efficiently. These recommendations were incorporated into the JOBS Act, which Congress passed in April 2012. The Act took effect immediately and was retroactively applied to IPOs completed after December 8, 2011.

Title I of the JOBS Act introduced Emerging Growth Companies (EGCs), defined as issuers with annual revenues below $1 billion in the most recent fiscal year before issuance. EGCs were granted significant regulatory relief in terms of disclosure and governance obligations. Key provisions included the ability to confidentially submit registration statements for SEC review, engage with prospective investors to gauge interest, provide streamlined executive compensation and financial disclosures, and gain exemptions from Sarbanes-Oxley (SOX) Section 404 and Dodd-Frank Act say-on-pay rules. Based on a hand-collected dataset of IPO prospectuses, we find that the average EGC in our sample implemented five of the six de-burdening provisions, suggesting that firms generally perceived the reduced regulatory requirements as beneficial despite potential costs.

The enactment of the JOBS Act is widely regarded as one of the most significant and unanticipated reforms to U.S. securities laws affecting the IPO process (e.g., Dambra et al. 2015). This legislative change therefore offers a unique opportunity to examine the impact of regulatory relief on the innovation outcomes of newly public firms. However, the regulatory

relief will not affect all going-public firms equally. Consider, for example, an innovative start-up whose products are mostly or entirely in the earliest exploration and development stage (and yet to be marketed). Such an early-stage firm differs fundamentally from a more mature-stage firm in terms capital needs, strategic priorities, innovation strategy, and agency conflicts. Theoretical and empirical research by Abernathy and Utterback (1978), Klepper (1996), and Argente et al. (2024) underscores that product life cycle dynamics significantly influence firms' revenue growth, cash flows, and industry dynamics. Moreover, product dynamics also determines the type of investment projects firms undertake and how they finance them (Hoberg and Maksimovic 2022; Hajda and Nikolov 2022).

Our central premise is that the JOBS Act's impact on a firm's innovation performance depends on its exposure to early stages of the product life cycle. However, the net innovation effect of the Act is ambiguous due to competing influences.

On one hand, the Act's regulatory relief—intended to lower the costs and risks of going public—should disproportionately benefit early-stage firms. These firms, often characterized by limited internal liquidity and heavy reliance on external financing, are likely to experience the greatest gains in capital raised through IPOs and subsequent investments.

On the other hand, increased R&D expenditure, a common measure of innovative effort, does not necessarily translate to greater or higher-quality innovation outcomes. In many industries, the innovation process is expensive, protracted, and fraught with uncertainty regarding scientific feasibility and market viability (Jones 2009, 2022). Early-stage firms, which typically pursue exploratory innovations to develop novel products (Akcigit and Kerr 2018), face particularly high risks. For example, in biotechnology and pharmaceuticals, early-stage firms invest heavily in R&D, yet fewer than 25% of their products reach commercial success (DiMasi et al. 2016). While successful outcomes can transform a firm's competitive

position, failures are especially costly for these firms, which often adopt high-risk, high-reward strategies (Levinthal and March 1993).

Furthermore, transitioning from private to public ownership can significantly alter managerial and inventor incentives. Exploratory innovation thrives in environments where managers have substantial autonomy over innovation strategies (Holmstrom 1989). However, public firms often face pressure from investors to prioritize short-term performance, which may discourage high-risk innovation strategies. Empirical evidence from Bernstein (2015) suggests that going public can lead to the departure of key employees and shifts in innovation strategy as firms respond to public market pressures. Additionally, the transition to public ownership may exacerbate the "overinvestment" agency problem. As Sahlman (1990) notes, entrepreneurs may continue to overinvest in unviable R&D projects as long as external capital remains available. While venture capitalists, the typical pre-IPO financiers of early-stage firms, mitigate this risk through staged funding (Kaplan and Strömberg 2003), the infusion of IPO proceeds may encourage managers to undertake excessively risky projects or persist with unsuccessful ones. Reduced disclosure and governance requirements under the JOBS Act may further diminish pressure on managers to allocate resources efficiently.

In sum, we argue that the distinct profile of early-stage firms makes them particularly sensitive to regulatory relief. Balancing these countervailing forces (additional capital infusion, high project uncertainty, and changes in managerial incentives), we propose that the JOBS Act may yield (counterintuitive) differential for early-stage firms: despite raising more capital and investing more in R&D, these firms might achieve fewer successful innovations of lower technological and economic value compared to their mature counterparts.

3. Sample, Data, and Descriptive Statistics

3.1 Sample selection

Our sample comprises firms at the intersection of the IPO, patents, product life cycle, and CRSP/Compustat databases. The dataset includes all U.S.-based firms that completed an IPO

of ordinary common stock on the NYSE, AMEX, or NASDAQ between January 2003 and December 2018, as reported in Refinitiv's SDC database. The sample period is designed to balance the number of observations before and after December 8, 2011, when the EGC classification under the JOBS Act took effect. The cutoff in December 2018 ensures at least five full years of post-IPO data on patent applications, forward citations, and firm survival (and accounting for the average two-year lag between patent applications and grants).

From the SDC database, we collect detailed IPO information, including the offer date, offer price, issue description, industry classification, total shares sold, primary and secondary shares, proceeds raised, marketplace of issuance, offer price revisions, underwriter details, and venture capital backing. Consistent with IPO literature, we exclude rights offerings, private placements, spin-offs, unit offers, reverse leveraged buyouts, and offerings by financial firms, limited partnerships, trusts, REITs, governments, or quasi-public entities. IPOs with proceeds under $1 million are also excluded. Firms must have stock data available on CRSP within five days of the IPO and valid pre-IPO asset data on Compustat. Additionally, firms must have filed an IPO prospectus and at least one 10-K report in the SEC's EDGAR database to extract product life cycle information. Firms with pre-IPO annual revenues exceeding $1 billion are excluded to maintain consistency with EGC eligibility criteria, resulting in an initial sample of 1,098 firms.

Finally, because our analysis focuses on patent-based metrics that have no obvious relevance for non-patenting firms, we include only firms with at least one successful patent application within five years before or after the IPO filing date. This restriction yields a sample of 746 innovative firms, 381 of which went public after the Act's effective date.

3.2 Measuring Innovations and Innovation Quality: Patent Metrics

For each firm in our sample, we collect data on all utility patent applications filed with and subsequently granted by the U.S. Patent and Trademark Office (USPTO) between January 1, 1998, and December 31, 2023. This data is sourced from datasets compiled by

Kogan et al. (2017), Kelly et al. (2021), Stoffman et al. (2022), and Arora et al. (2024), which we update to include more recent patents and citation information from the USPTO PatentsView database. These datasets provide detailed information on patent assignees, technology classes, application and grant dates, backward and forward citations (references cited by and citing the patent), and firm identifiers, which allow us to merge the patent data with CRSP and Compustat.

To capture various dimensions of firm innovation output, we employ a combination of traditional and recently developed patent-based metrics commonly used in the innovation literature. Our primary measure of innovative output is the count of patent applications filed within a specific period, which are eventually granted by the USPTO. Following standard practice, we use the patent application date rather than the grant date, as it aligns more closely with the timing of the underlying innovation (Griliches, 1990).

Patent counts alone, however, do not capture differences in the scientific/technological importance or economic value of patents (e.g., Lanjouw & Schankerman, 2004; Hall et al. 2005). To address this, we measure technological importance with different metrics. The first metric is the number of forward citations a patent receives within five years of its grant date, which reflects its perceived scientific and technological impact (Griliches, 1990; Albert et al. 1991). Since forward citation counts can be affected by temporal and technological factors- such as shifts in technology relevance or truncation bias- we follow Arora et al. (2023) by scaling each patent's citation count relative to the average citations received by other patents filed in the same year and 3-digit Cooperative Patent Classification (CPC) technology class.

Because forward citation distributions are highly skewed- where a small number of patents receive a disproportionate share of citations- we include a second metric of technological importance: breakthrough patents. Breakthrough patents are defined as those in the top 10% of most-cited patents in their application year (e.g., Aghion et al. 2024).

We also measure patent scope, which represents the breadth of intellectual property protection. As argued by Lerner (1994), patents with broader scope mat enable firms to extract greater monopoly rents and therefore create more value. Following Marco et al. (2019), we measure patent scope as the number of independent claims in a patent application, with a higher number indicating broader protection.

Lastly, we assess the economic value of patents using the methodology of Kogan et al. (2017), which is based on short-term stock market reactions to patent grant announcements, adjusted against a relevant benchmark. The resulting change in a firm's market value is an indicator of the patent's anticipated economic benefits (see also Stoffman et al. 2022). Importantly, this measure captures private value- such as competitive advantages and patent marketability- distinct from purely scientific importance.

3.3 Measuring product life-cycle stage

We define each firm's product life cycle stage at the time of its IPO using a newly developed approach and dataset from Hoberg and Maksimovic (2022). These authors apply textual analysis to financial statements to classify the life cycle stages of a firm's product portfolio. Drawing on the influential framework by Abernathy and Utterback (1978), they categorize products into four life cycle stages. In the earliest stage (Stage 1), firms focus on product exploration and development. The intermediate stages (Stage 2 and Stage 3) involve marketing products and expanding revenues and cash flows. In the final stage (Stage 4), products become obsolete, and cash flows decline. Each firm's product portfolio is represented as a four-element vector, [Stage1, Stage2, Stage3, Stage4], with each value indicating the fraction of the portfolio in the respective stage, summing to one. Notably, Hoberg and Maksimovic demonstrate that the product life cycle stage influences cash flows and investment policies independently of firm age or size, as firms can transition between stages over time.

To validate this classification, we extend Hoberg and Maksimovic's methodology by analyzing IPO prospectuses. We find that firms with a high proportion of products in Stage 1 use distinct language to describe their product life cycles and associated risks compared to firms with more mature products. Early-stage firms typically highlight exploratory activities, limited revenues, and plans for significant investments in product development. For example, Apellis Pharmaceuticals, with approximately 70% of its products in Stage 1, states in its IPO prospectus: "*We have not … completed the development of any product candidate and … are dependent on the successful development and commercialization of APL-2*." In contrast, firms with more mature products emphasize market expansion and revenue growth. For instance, Cardlytics Inc., with about 20% of its products in Stage 1, states: "*We have proven the power of purchase intelligence with our proprietary native advertising channel … We are extending the power of our platform beyond Cardlytics Direct. As we built scale …*"

To quantify a firm's exposure to the early stage of the product life cycle - our treatment intensity - we measure the fraction of products in Stage 1. This constructed measure, *Early Product Stage*, aligns with our analytical framework, which posits that the innovation effects of regulatory reform vary depending on a firm's exposure to the earliest life cycle stage of its products.

3.4 Descriptive Statistics

Figure 1 illustrates the yearly frequency of our innovative IPOs alongside the time-series average proportion of IPO firms' products at the early product life cycle stage (Stage 1). The number of IPOs fluctuates significantly over the years, peaking in 2007 and 2014. IPO activity sharply declined following the 2008-2009 global financial crisis and did appear to recover somewhat following the passage of the JOBS Act. While not shown, the distribution of innovative IPOs as a percentage of all IPOs varies from a low of 42% in 2003 (16 out of 38 IPOs) to as high as 84% (57 out of 68) in 2015. The dynamics of the fraction of Stage 1 products in the overall product portfolio of an average firm largely mirrors the IPO count

dynamics. The average proportion of early-stage products notably increased in the post-JOBS period: from 36% over 2003-2007 to almost 47% over 2014-2018. Thus, the JOBS Act appears to be associated with a long-term sustained increase in IPO volume by firms with more early-stage products.

Regarding the industry composition (unreported), most of our sample offerings are concentrated in knowledge-intensive industries that rely extensively on patens for the legal protection of their inventions such as biotech and pharmaceuticals, electronic equipment, computer hardware and software, and medical equipment. The composition of patents across technology classes (CPC) is very similar with most patents from computers, biological and chemical drugs, and electronics.

Panel A of Table 1 compares the means and medians of the selected key characteristics at the time of the IPO between issuers before and after the passage of the Act, along with the p-values from the tests of the differences. The medians of almost all variables are generally significantly lower than the means, indicating that the data is positively skewed. There are no significant differences in assets, sales, the amount of IPO proceeds scaled by pre-IPO assets, and leverage between the two periods, suggesting that the age, size, and financial structure of issuers have not materially changed around the Act. Notably, firms going public after the Act's enactment are significantly less profitable and spend more on R&D, which is consistent with the result in Figure 1 that the Act has potentially encouraged IPOs among firms with early-stage products. All these differences are intuitive: firms with products in the early stages are yet to generate large stable revenues and must devote more resources to R&D and marketing new products. This conjecture is further supported by a significant increase in VC-backed IPOs in the post-JOBS period (83.6% vs. 75.1%) venture capital backing is more prevalent among early-stage companies. The other notable statistics of that both mean and median first-day returns are significantly higher in the post-JOBS period (20.5% vs. 12.8%

for mean, 13.2% vs. 7.1% for median). This is consistent with the evidence in Barth et al. (2015) of an increased cost of equity capital for going public firms in the post-JOBS period due to lower information disclosure requirements. It is important to note that despite the shift to earlier-product life cycle stage IPOs following the passage of the Act, the average and median age of pre- and post-JOBS firms are not statistically different. This is consistent with Hoberg and Maksimovic (2022) that the product life cycle stage is distinct from a firm age.

Panel B of Table 1 presents statistics on the mean, standard deviation, and the 25th and 75th percentiles of firms' product life-cycle stages before and after the passage of the Act. Firms typically have products in all four life-cycle stages. Most notably, the differences in product life cycle once again highlight a significant increase in the early-stage IPOs in the post-JOBS period. On average, post-JOBS issuers have about 45% of their products in Stage 1 while this number is 36% for the pre-JOBS issuers. The difference is significant at the 5% level. Conversely, pre-JOBS IPOs have a greater proportion of their products in Stage 2 and Stage 3. Both groups of firms have less than 3.4% of their products in the discontinuation stage of their life cycle.

We next presents univariate evidence on IPO firms' patenting activities around the JOBS Act. Panel A of Figure 2 depicts event-time averages of the likelihood of obtaining at least one patent in each of the three years before and after an IPO, separately for pre- and post-JOBS IPOs. Both groups exhibit an upward trend in patent likelihood prior to their IPOs, peaking in the IPO year or the year after, followed by a gradual decline. This pattern is more pronounced among post-JOBS issuers, suggesting that the Act may have made IPOs more accessible and appealing to innovative private firms.

Panel B of Figure 2 displays event-time averages of the number of patents per firm. Across both periods, the average number of patents steadily increases from three years before the IPO to three years after. Pre- and post-JOBS firms exhibit similar patent counts and

breakthrough patents before their IPOs, indicating no discernible pre-issuance trends in innovation output. However, the rate of growth in patent counts is higher in the post-JOBS period, suggesting that regulatory reforms facilitated increased patenting activity post-IPO.

Table 2 complements these findings by providing univariate tests of mean patenting activity during the two years before and after the IPO for both pre- and post-JOBS periods. Consistent with Figure 2, the differences in pre-offering patent counts and citations between the two groups are not statistically significant, indicating comparable innovation levels before going public. Post-offering differences, however, are significant: post-JOBS firms outperform pre-JOBS firms in patent filings, scope, and the market value of patents. Notably, post-JOBS IPOs demonstrate substantially higher patent valuations, suggesting that investors attach greater value to innovations produced by post-JOBS firms.

4. Empirical Strategy and Results

4.1 Empirical Strategy

Our central hypothesis is that the impact of the regulatory relief provided by the JOBS Act on IPO firms' innovation performance varies depending on the life cycle stage of their products. To test this hypothesis, we use the following generalized difference-in-differences (DiD) framework:

$$InnovationOutcome_{i,t} = \delta_{i,t} + \beta_1 POST\text{-}JOBS \times Early\ Product\ Stage_{i,} + \beta_2 POST\text{-}JOBS + \beta_3 Early\ Product\ Stage_{i,} + B_4 Pre\text{-}IPO\ Innovation\ Output_{i,t} + \gamma_j \times Firm\ and\ Issue\ Characteristics_{,i\ t=0} + Industry\ FE + Time\ FE + \varepsilon_{ist} \quad \textbf{(1)}$$

Here, *i* indexes firms, and *t* denotes the calendar year of the IPO.

In our main empirical models, *Innovation Outcome* is the natural logarithm of the number of patents (plus one) a firm produces within two full years of going public. Results remain consistent when using a three-year window. This framework is also employed to analyze additional patent-based metrics, as discussed in Section 3.2.

POST-JOBS is an indicator variable equal to one for firms that went public after the effective date of the JOBS Act (December 8, 2011), and zero otherwise. *Early Product Stage* is our continuous treatment intensity and is measured as the fraction of firm products in the earliest life cycle stage. Our main variable of interest is the interaction term *POST-JOBS*× *Early Product Stage,* with the coefficient β_1 capturing the differential impact of the Act on early-stage versus mature-stage firms. *Pre-IPO Innovation Output* measures firm innovation (e.g., patents, citations) during the two years preceding the IPO, serving as a quasi-fixed effect to account for potentially persistent firm-specific factors influencing innovation.

The DiD framework identifies two margins of comparison. First, *POST-JOBS* captures the difference in innovation output between firms that went public before and after the Act. Pre-Act IPO firms (non-EGCs) serve as an effective control group, as they would have qualified for the Act's relief had they gone public later. Second, the interaction term *POST-JOBS*×*Early Product Stage* captures differences in innovation outcomes across firms with varying exposure to early-stage products. Mature-stage firms serve as a counterfactual, representing the innovation outcomes expected for early-stage firms had they been at a more advanced life cycle stage.

The specifications include a set of issuer, deal, and industry and overall market characteristics as control variables, consistent with prior IPO studies such as Bernstein (2015). To control for the potentially greater propensity of larger-size issuers to produce more innovations, we include firm size as measured with the natural logarithm of book assets. To control for financial capacity and profitability, we include the amount of long-term debt and operating income, both scaled by book assets. To control for the capital infusion from the offering, we include the amount of IPO proceeds scaled by total assets. All these accounting variables are measured as of the end of the fiscal year preceding the IPO.

Deal-level controls include IPO underpricing, venture backing, and underwriter reputation. *IPO Underpricing,* measured as the first trading day return, may reflect firm quality and investment opportunities (Grinblatt and Hwang, 1989) while the *Venture-Backed* indicator accounts for certification effects provided by venture capitalists (Megginson and Weiss, 1991). Underwriter reputation can be related to the certification effects of reputable IPO underwriters (e.g., Carter and Manaster 1990) and is measured with the underwriter rankings obtained from Jay Ritter's website. Underwriter rankings range from zero (least prestigious) to nine (most prestigious). Finally, to control for market and industry conditions influencing IPO valuation and investment, we include the industry average market-to-book ratio, and the market return over the six months preceding the IPO.

Industry fixed effects (at the Fama-French 12 industry level) absorb any persistent industry-specific differences in patenting activity or productivity that could influence firm innovation. IPO year fixed effects absorb any economy-wide shocks and the mean innovation output across the entire sample a given year and thus control for temporal factors that may differentially affect the behavior of firms before and after the Act. Statistical inferences are based on robust standard errors clustered at the calendar year level. Results are robust to alternative clustering at the industry or year-by-quarter levels.

4.2 Validation of the setting

Before proceeding with the analysis, it is essential to establish empirical support for the our argument that the JOBS Act significantly influenced key IPO outcomes and that this effect varies according to the product life cycle. To this end, we examine whether the Act affected the amount of IPO proceeds raised and subsequent R&D expenditures, focusing on differences across firms with varying exposure to the early product life cycle stage.

Table 3 presents the estimates of a specification similar to Eq. (1) but using the amount of IPO proceeds and total spending on R&D over the first two post-IPO calendar years. We first

estimate the specification by suppressing the time-fixed effects which allows us to estimate the average effect captured by *POST-JOBS* and its interaction with *Early Product Stage.*

In Column 1, using IPO proceeds scaled by pre-IPO assets as the dependent variable, we find that the coefficient on *POST-JOBS*Early Product Stage* is positive, 2.72, while the coefficient on *POST-JOBS* is negative, -0.878. Both coefficients are significant at the 1% level. The results are economically meaningful. Using the estimates, we calculate that an average post-JOBS IPO firm with no Stage I products raises 41% less proceeds as a percentage of assets relative to the mean of the pre-JOBS group (*=-0.875/2.136*). In contrast, the positive interaction term suggests that greater exposure to early-stage products enhances capital raising: a post-JOBS firm at the 75th percentile of Stage 1 product distribution raises 67.2% more capital as a percentage of assets than a firm at the 25th percentile *(=2.72 × (0.574 - 0.327)*).

Finally, the coefficient on *Early Product Stage* alone is negative and significant at the 1% level, indicating that, on average, early-stage firms in the pre-JOBS period generally raised relatively less capital. In Column 2, we add fixed effects for the IPO issue year which absorb any confounding omitted variables that vary at the year level and thus suppress the coefficient on *POST-JOBS*. We see an almost identical point estimate on *POST-JOBS*Early Product Stage* (coefficient 2.676) with similar significance which suggests that the observed capital-raising differentials are largely independent of macroeconomic trends.

Columns 3 and 4 analyze R&D expenditures over the two years following the IPO, scaled by pre-IPO assets. The interaction term, *POST-JOBS×Early Product Stage*, yields positive and significant coefficients in both specifications, indicating that early-stage firms increased their R&D spending (as a percentage of assets) significantly more than mature-stage firms after the passage of the Act. In contrast, the coefficient on *POST-JOBS* in Column 3 is not

significantly different from zero, suggesting that the R&D spending of mature firms is unchanged around the Act.

These findings indicate that the JOBS Act benefited early-stage firms by enabling them to raise more capital, which they appear to direct toward increased R&D investment. This result aligns with the Act's stated objective of facilitating capital raising for emerging firms and fostering R&D spending. However, the critical question remains: Did these early-stage firms convert additional capital and R&D spending into increased patented innovation?

4.3 JOBS Act, Product Life Cycle and Patenting

To examine the marginal effects of the JOBS Act on IPO firms' innovation performance within the first two years after going public and whether these effects vary with product life cycle stages, we estimate variations of Eq. (1). The results are reported in Table 4.

We begin our analysis with a simplified specification in Column 1 that analyzes firms' post-IPO patent count without the product life cycle and pre-IPO innovation output variables and year-fixed effects, allowing us to estimate an easily interpretable average effect of the Act. The coefficient on *POST-JOBS* is positive 0.219 and significant at the 5% level, indicating a 24.5% increase in patents for post-JOBS firms relative to pre-JOBS firms ($=e^{0.219}-1$). Given an average of 11.35 patents in the first two post-IPO years for pre-JOBS firms (from Table 2), this corresponds to approximately three additional patents for an average post-JOBS issuer.

Column 2 adds the key interaction term *POST-JOBS*×*Early Product Stage*, along with *Early Product Stage*, but excludes time-fixed effects and pre-IPO innovation output. The key observation in this column is the strikingly different effects of the Act on issuers' innovation performance depending on their product life cycle stage. The coefficient on *POST-JOBS* increases in magnitude to 0.437 with a p-value<< 0.01, reflecting the positive impact of the Act for mature-stage firms (where *Early Product Stage* is or close to zero). By contrast, the coefficient on *POST-JOBS*×*Early Product Stage* is negative, -0.786, and significant at the 5%

level, indicating a significant reduction in innovation output for early-stage post-JOBS issuers. The economic effect is substantial: a post-JOBS issuer at the mean of the Stage 1 product distribution produces about 24% fewer patents than a post-JOBS mature-stage IPO with no Stage I products *((=$e^{-0.786}$ -1)× 0.445*), and a post-JOBS issuer at the 75th percentile of the Stage 1 product distribution generates 13.4% fewer patents than its peer at the 25th percentile *((=$e^{-0.786}$ -1)× (0.574 - 0.327)*). These results support the notion that an IPO firm's position in the product life cycle is a critical determinant of its innovation response to regulatory relief.

In Column 3, we estimate the full Equation (1), incorporating year-fixed effects and *Pre-IPO Innovation Output*. The inclusion of year-fixed effects renders the direct estimate of *POST-JOBS* unidentified. The coefficient estimate on *POST-JOBS*×*Early Product Stage* and its statistical significance remains stable following the inclusion of these additional controls, yielding a value of -0.813 with a p-value<0.05. This relative stability of the DiD coefficient suggests that the identified average differences in relative innovation output between early- and mature-stage firms before and after the passage of the Act are independent of macroeconomic conditions.

To ensure robustness, we next employ alternative specifications. The specification in Column 4 employs a Poisson pseudo-maximum likelihood regression, which effectively models count data even with a high proportion of zeros (e.g., Cohn et al. 2022). In this specification, we use the raw number of patents as the dependent variable. The results remain consistent, as the estimated coefficient on *POST-JOBS*×*Early Product Stage* is negative and significant at the 5% level, while the coefficient on *POST-JOBS* is positive and significant at the 10% level.

In Column 5, we scale patent counts by pre-IPO assets to address concerns that the findings may still be influenced by differences in firm size (e.g., Arora et al. 2023). Our

inferences remain consistent: *POST-JOBS×Early Product Stage* yields a negative and *POST-JOBS* yields a positive coefficient, both significant at better than the 5% level. These consistent findings from the alternative specifications help instill further confidence in our results. We performed several additional robustness tests (unreported but available upon request), including using a three-year post-IPO window instead of two years and restricting the sample to 2004-2017. The results remained consistent across these specifications.

Turning to the other independent variables, we observe that the *Early Product Stage* variable yields consistently positive and significant coefficients, suggesting that pre-JOBS firms with predominantly early-stage products produce higher innovation output on average. *Pre-IPO Innovation Output* also shows a positive association with post-IPO patenting, suggesting persistence in innovation performance. Firm size (measured by book assets) and venture capital backing are also consistently significant predictors of higher post-IPO innovation output.

In summary, our baseline results demonstrate that the JOBS Act's impact on the innovation performance of IPO firms is highly dependent on their exposure to the product life cycle stage. On average, post-JOBS issuers in the early stages of their product life cycle generated significantly fewer patented innovations in the two years following their IPOs compared to their more mature counterparts, despite raising more capital in the IPO and increasing R&D spending. This finding is consistent with the critical role of a firm’s position in the product life cycle in shaping its innovation response to regulatory relief.

4.4 Test of parallel trends assumption and placebo tests

A fundamental assumption of the DiD strategy is that, absent the regulatory reform introduced by the JOBS Act, the patenting activity dynamics of the treatment group would parallel those of the control group (Angrist and Pischke, 2008). This parallel trends assumption requires no significant differences in pre-JOBS Act patenting trends between

firms with varying exposure to early product life cycle stages. If this assumption is violated, our results could reflect pre-existing trends rather than the (causal) impact of the Act.

To test this assumption, we restrict the analysis to the pre-JOBS period and estimate a regression where *POST-JOBS* is replaced by a *Time Trend* variable, defined as the difference between the current year and 2002 (e.g., 1 for 2003, 2 for 2004, etc.). This approach allows us to examine whether firms with varying exposure to early-stage products exhibited differential trends prior to the Act (which would be captured by the coefficient on the interaction term *Time Trend*×*Early Product Stage*).

Table 5 presents the results of this modified specification. The key result is that the coefficient on the interaction term *Time Trend*×*Early Product Stage* is not statistically significant, indicating no evidence of preexisting differences in patenting trends between treated and control groups. *Time Trend* also yields an insignificant coefficient. These results help mitigate concerns that our findings may be driven by preexisting differences rather than the JOBS Act's impact.

To further validate our approach, we conduct a placebo test in Column 2 of Table 5. This test addresses any lingering concerns that omitted variables or preexisting conditions might differentially affect early-stage versus mature-stage firms before the Act. We simulate a placebo event by shifting the JOBS Act's effective date to December 2008, three years before its actual implementation. The logic is that, in the absence of differential preexisting trends, this pseudo-event should yield no significant innovation effects. Consistent with this expectation, the placebo results show that the coefficients for *POST-JOBS* and *POST-JOBS* × *Early Product Stage* are negligible and statistically insignificant.

These findings suggest that our results are unlikely to be confounded by omitted variables or concurrent differential trends coinciding with the Act's implementation. By confirming the

validity of the parallel trends assumption and ruling out alternative explanations, these robustness tests reinforce the causal interpretation of our results.

4.5 Analysis of the technological and market value of inventions

The analysis thus far has relied on patent counts as a measure of firm innovativeness. However, as discussed in Section 3.2, patent counts may obscure critical differences in the technological value and strategic focus of innovations across firms. A plausible explanation for the baseline results is that early-stage firms going public after the JOBS Act shifted their strategy toward producing fewer but more technologically significant innovations.

To test this alternative argument, we examine three measures of forward-looking technological quality: (1) the average number of adjusted forward citations per patent, (2) the number of breakthrough patents, and (3) the average patent scope. As with patent counts, we use the natural log transformations of these variables (plus one). These additional patent metrics provide a more comprehensive assessment of how regulatory reform affects not only the quantity but also the quality and thus potentially the direction of post-IPO innovation.

Table 6 replicates the specifications from Columns 2 and 3 of Table 4 using these technological quality measures as dependent variables. The key takeaway is that the results here consistently align with our earlier findings based on patent counts. For example, in Column 1, using the breakthrough patent count as a measure of patent technological value, we find that the coefficient on *Post-JOBS*×*Early Product Stage* is negative, -0.667, and significant at the 5% level. Conversely, the coefficient on *Post-JOBS* is positive, 0.21, and significant at the 10% level. These estimates imply that a post-JOBS IPO at the mean of the Stage 1 product distribution generates approximately 22% fewer breakthrough patents compared to a mature-stage counterpart with no Stage 1 products (which in contrast produces 23% more breakthrough patents relative to the pre-reform mean).

Similar results emerge using forward citation count and patent scope as the dependent variable, although results for patent scope are only marginally significant. Overall, these

findings suggest that the Act's regulatory relief had a detrimental impact on the post-IPO technological quality of early-stage firms' innovations relative to mature-stage firms.

We next examine the Act's effect on the value created by patents for firm shareholders. As discussed in Section 3.2, patent market value captures not only technological quality but also broader value-relevant factors such as marketability and competitive advantage. Since market value cannot be computed for private firms, we use pre-IPO adjusted citation counts as a proxy for pre-IPO innovation output, controlling for initial innovation quality.

Table 7 follows the structure of the previous table, with Columns 1 and 2 using average patent value scaled by the market value of equity at the IPO as the dependent variable, and Columns 3 and 4 using the natural logarithm of average patent value (in millions of dollars). Consistent with previous findings, the results indicate that the Act's impact on patent value varies with firms' varying exposure to the early product life cycle stage. The interaction term *Post-JOBS* × *Early Product* yields negative coefficients, significant at the 5% level across all specifications. Conversely, the *Post-JOBS* variable produces positive coefficients, significant at the 1% level in specifications without time-fixed effects. The estimates in Column 1 suggest that a post-JOBS IPO at the mean of the Stage I product distribution produces patents that are 32.3% less valuable (as a percentage of the market value of equity) than those of a post-JOBS mature-stage IPO with no Stage I products *(=-0.727 × 0.445*). Given a mean patent value of 5.61% of pre-IPO assets in the post-JOBS period, this decrease is economically meaningful.

Overall, these findings provide strong evidence of the JOBS Act's divergent effects on innovation for firms going public at different stages of the product life cycle. On average, early-stage firms experienced declines in the technological quality and market value of their innovations in the post-Act period compared to mature-stage firms (which experienced the opposite effect, benefiting from increased innovation quality and private value).

4.6 Acquiring Innovation Through M&A

Our analysis thus far has focused on internally generated patents. However, firms frequently acquire patents through mergers and acquisitions (M&A)(e.g., Bena and Li, 2014). Previous research highlights M&A activity as a key factor in firms' decisions to go public and their post-IPO strategies (Brau and Fawcett, 2006; Celikyurt et al. 2010; Alimov and Mikkelson, 2012). To provide a comprehensive assessment of the JOBS Act's impact on IPO firms' innovation performance, we now extend our previous analysis to externally acquired innovations. It is plausible that the JOBS Act, by facilitating capital raising, may have encouraged IPO firms- particularly early-stage companies - to acquire patents through M&A as a complement to or substitute for internal innovation production.

We collected data on all M&A transactions completed by our sample firms within the first two post-IPO years from the SDC database. We included transactions in which acquirers gained control of targets (ownership increased from less than 50% to more than 50%) and classified as "Merger" or "Acquisition of Assets/Certain Assets/Majority Interest." 235 of our sample firms completed at least one acquisition during this period, acquiring 494 targets in total, about 95% of which were private firms. By matching target firm names with patent assignee names in the USPTO database, we identified patents awarded to targets before their acquisition. Collectively, our firms acquired 1,927 patents within two years of their IPO, compared to 9,992 internally produced patents during the same period. These findings confirm that the purchase of external innovations is a key driver of the M&A activity of newly public firms.

To evaluate the JOBS Act's impact on externally acquired innovations, we estimate the Eq. (1), using the natural log of external patents acquired through M&A within the first two post-IPO years (plus one) as the dependent variable. Table 8 presents the results, with Columns 1 and 2 reporting regressions excluding and including year-fixed effects, respectively. In both columns, the coefficient on *POST-JOBS* × *Early Product Stage* is

negative (-0.235 and -0.259, respectively) and statistically significant at the 5% level. These findings indicate that early-stage firms going public after the Act acquired fewer external patents relative to their mature-stage counterparts. Conversely, the coefficient on *POST-JOBS* in Column 1 is positive and significant, suggesting that mature-stage post-JOBS firms increased their acquisition of external innovations compared to the pre-JOBS group.

Overall, these findings demonstrate that the JOBS Act influences not only internally generated but also externally acquired innovations of IPO firms in the same direction and that the effects vary systematically depending on the firm's product life cycle stage.

4.7 JOBS Act, Product Life Cycle, and IPO Failure

Our main findings indicate that the reduction in regulatory burdens introduced by the JOBS Act has a detrimental impact on both internal and external innovation outputs for issuers in the early stages of the product life cycle, compared to their more mature counterparts. Given the critical role of innovation in firm competitiveness and survival (e.g., Somaya, 2012), our final analysis examines the Act's impact on the long-term viability of IPO firms.

Following established IPO literature (e.g., Fama and French, 2004; Alimov and Mikkelson, 2012), we classify IPO failures based on firms' listing status. All sample firms were initially listed on the NYSE, AMEX, or Nasdaq, exchanges that enforce minimum requirements for performance, market capitalization, and stock price. A firm is classified as a "failure" if it is involuntarily delisted within three or five years of its IPO due to liquidation (CRSP delisting codes 400–490) or poor performance (codes 500 and 535–590, excluding 573 for "gone private"). All other firms, including those acquired, are classified as "non-failures."

In our data, exchange delistings due to poor performance occur primarily after the third year post-IPO. By year three, 1.2% of sample firms are classified as failures, increasing to

4.4% by year five. In contrast, acquisition-related delistings are more prevalent, with 6.7% and 15.9% of firms being acquired within three and five years, respectively.

To quantify the JOBS Act's impact on IPO firm viability, we estimate logistic regressions on the likelihood of failure, using delisting due to poor performance within three or five years as the dependent variable. Table 9 reports the odds ratios derived from these regressions, employing the same independent variables and structure as in previous analyses.

The results are once again striking: the coefficient on *POST-JOBS*×*Early Product Stage* is positive and significant at the 5% or 1% levels across all specifications. The odds ratios suggest that a post-JOBS IPO at the mean of the Stage I product distribution has 5.39 to 6.8 times higher odds of failing within three or five years compared to their mature-stage counterparts. In contrast, the coefficient on *POST-JOBS* is negative and significant at the 1% level (in specifications without year-fixed effects), indicating significantly lower failure odds for mature-stage post-JOBS issuers[2]. Notably, among all the independent variables, only these two variables have the largest and consistently significant impact on firms' failure odds within three and five years of going public.

These findings strongly suggest that potentially suboptimal innovation performance has severe consequences for newly public firms. It seems that early-stage issuers' apparent failure (due to technical or agency-related reasons) to convert increased R&D spending into tangible innovations after the JOBS Act significantly raises their risk of exchange delisting due to poor performance. By contrast, mature-stage firms appear to benefit from the Act's regulatory relief leading to superior innovation outcomes and improved long-term survival prospects.

[2] Unreported analyses of three-year buy-and-hold abnormal stock returns reveal similar patterns, with early-stage post-act firms experiencing significantly worse stock performance relative to mature-stage peers.

5. Conclusion

This study provides novel evidence on the impact of regulatory reforms on the innovation performance of IPO firms, exploiting the 2012 JOBS Act as a source of major policy change. Our findings reveal that the Act's effects on innovation are highly divergent and significantly influenced by a firm's position in the product life cycle.

Consistent with the Act's stated objectives, firms going public in the earliest stage of the product life cycle raised more capital during their offerings and subsequently increased R&D spending, compared to their more mature-stage peers. However, early-stage firms produce fewer patents, which were also of lower technological quality and economic value, than their mature-stage counterparts. Moreover, early-stage firms acquired fewer external innovations post-IPO compared to their mature-stage peers, compounding their inability to bolster innovation through internal or external means. In the end, this failure to generate more innovations was associated with increased failure rates, evidenced by a higher likelihood of delisting due to poor performance. In contrast, mature-stage firms appear to have benefited from the Act's regulatory relief, despite raising relatively less capital. These firms enhanced the quantity, quality, and market value of their patents, evidently being able to effectively leverage the reduced regulatory burdens to bolster their innovation performance.

These findings have important implications for scholars, policymakers, and regulators. They underscore the nuanced relationship between regulatory relief, firm characteristics, and innovation, challenging the assumption that reducing regulatory burdens might foster innovation of all firms equally. Instead, the effectiveness of such policies depends critically on firms' position in the product life cycle stage. These insights are particularly relevant for ongoing regulatory and legislative discussions aimed at promoting a vibrant IPO market, such as the ongoing debate surrounding the proposed legislation "H.R.2793 - Encouraging Public Offerings Act".

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Appendix A: Key Variable Descriptions

Variable	Description
Post-JOBS	Indicator variable that equals 1 for IPOs that took place after December 8, 2011, and 0 otherwise.
Early Product Stage	The fraction of firm products in the earliest life-cycle stage, Stage 1
Patent count	The total number of patents that a firm applies for within a specific period, e.g., within two years of going public. Note: these are eventually granted by the USPTO.
Patent forward citations	The number of forward citations a patent receives in the five years after the grant data. In regressions, we scale forward patent citations by the average number of citations received by other patents granted in the same 3-digit CPC technology class and application year.
Breakthrough Patents	A patent that is in the top 10% of the most cited patents in its application year.
Patent Scope	The number of independent claims made by a firm's patents.
Patent value	The average market value of firm patents as measured by stock market reaction to patent grant announcement (from Kogan et al. 2017).
Failure within three or five years of going public	Indicator variable if the IPO is involuntarily delisted due to liquidation (codes 400–490 in the CRSP event file) or poor performance (codes 500 and 535–590, excluding 573 "gone private").
Log Assets	Log of pre-IPO total book assets in US dollars.
Firm Age	IPO year - year the IPO firm was founded or began operations
IPO Proceeds/assets	The total amount of funds from the sale of primary shares in the offering / pre-IPO total assets.
Oper.Income/assets	Operating income before depreciation, interest, taxes, and extraordinary items / pre-IPO total assets.
Book Debt/assets	(Short-Term Debt + Long-Term Debt)/Total Assets.
Venture backed (1/0)	Dummy variable if the IPO was backed by a venture capital firm as reported by the SDC.
Underwriter rankings	Range from zero (least prestigious) to nine (most prestigious). The data is obtained from Jay Ritter's website. https://site.warrington.ufl.edu/ritter/ipo-data/
IPO 1-st day return	The return on shares on the first trading day.
Market return	The return on CRSP index over the six months preceding the IPO date
Industry market to book	An industry average market to assets ratio at the end of the last-pre IPO fiscal quarter of the sample firm's IPO.

Figure 1: Yearly Frequency of Innovative IPOs and their Product Life Cycle

This figure shows the yearly frequency of our sample of IPOs between 2003 and 2018 and the average fraction of their products in the earliest product life cycle stage (Stage 1).

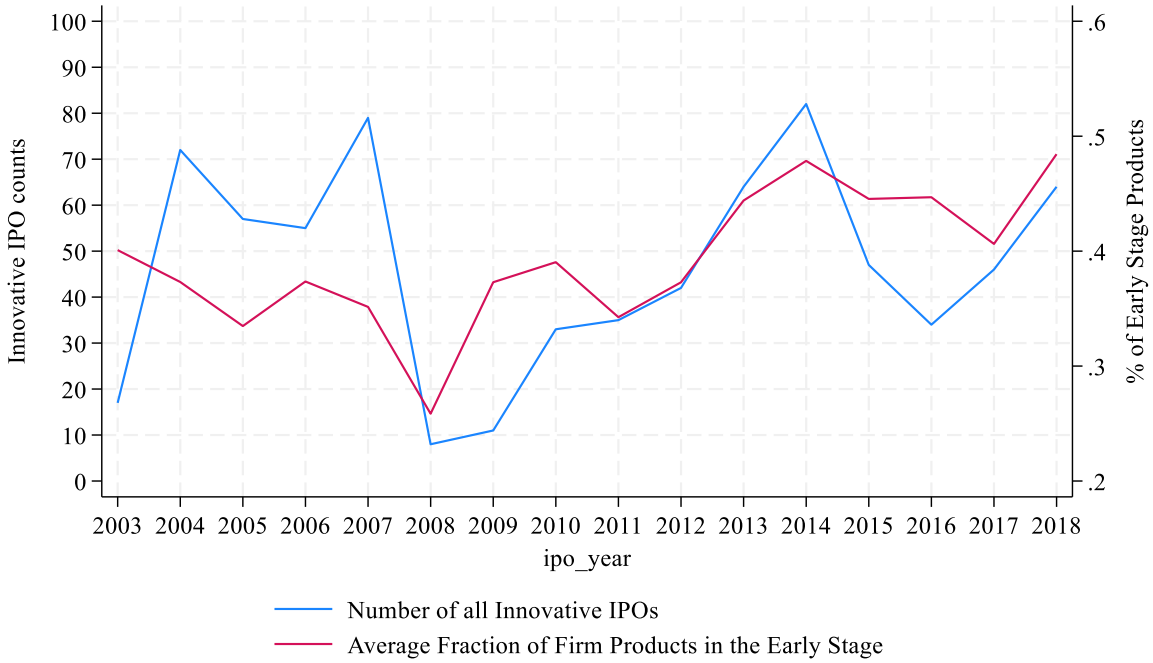
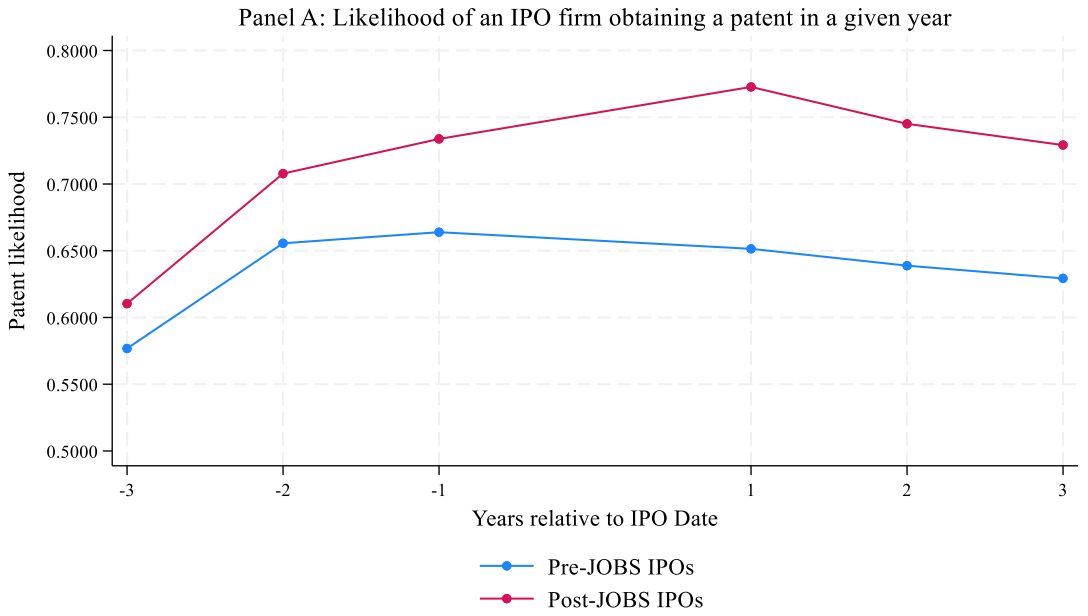


Figure 2: Patent Likelihood and Patenting Rates Around the IPO Date

This figure shows the average likelihood of IPO firms obtaining a patent in a given calendar year (relative to the IPO date) in Panel A and the mean number of patent application per sample firm in a given year in Panel B.



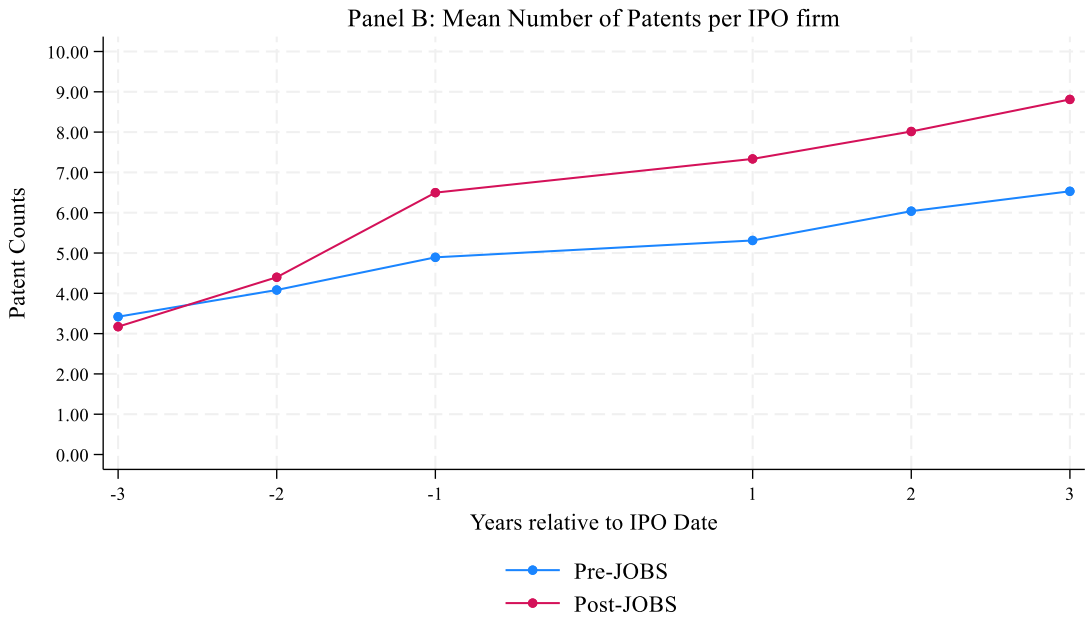


Table 1. Characteristics of the IPOs

The sample is U.S. initial public offerings (IPOs) of common stock in the years 2003-2018. All accounting variables are measured at the end of the fiscal year preceding an IPO. See Section 3.2. and Appendix A for detailed variable definitions. The mean and median values are reported for each characteristic within each subsample.

Panel A: Characteristics of IPOs in the PRE- and POST-JOBS Act Periods

Variable		PRE-JOBS	POST-JOBS	p-value of dif.
Book Assets in $mil	*Mean*	139.60	118.80	0.32
	Median	44.70	50.64	0.925
Annual Sales in $mil	*Mean*	102.18	83.58	0.133
	Median	34.70	22.52	0.078
Oper.Income/Assets	*Mean*	-0.29	-0.55	0.007
	Median	-0.04	-0.26	0
Age (in years)	*Mean*	18.30	12.58	0.164
	Median	8	9	0.149
Debt/Assets	*Mean*	0.43	0.44	0.949
	Median	0.12	0.11	0.658
Cash/Assets	*Mean*	0.38	0.52	0
	Median	0.35	0.50	0
Capex/Assets	*Mean*	0.06	0.05	0.12
	Median	0.04	0.02	0
R&D/Assets	*Mean*	0.42	0.60	0.03
	Median	0.27	0.31	0
IPO Underpricing (1st day return) in %	*Mean*	12.8%	20.5%	0
	Median	7.1%	13.2%	0.002
IPO proceeds/Assets	*Mean*	2.136	2.471	0.154
	Median	1.425	1.541	0.188
VC backed dummy	*Mean*	0.751	0.836	0.003
Number of IPOs		365		381

Panel B: Product Life Cycle:

Pre-JOBS IPOs:

Fraction of products in	mean	st. dev	25th percent	75th percent
Early Development: Stage 1	0.361	0.131	0.268	0.448
Process: Stage 2	0.36	0.113	0.278	0.421
Maturity: Stage 3	0.245	0.103	0.165	0.322
Discontinuation: Stage 4	0.034	0.034	0.013	0.048

Post-JOBS IPOs:

Fraction of products in	mean	st. dev	25th percent	75th percent
Early Development: Stage 1	0.445	0.142	0.327	0.574
Process: Stage 2	0.301	0.104	0.226	0.357
Maturity: Stage 3	0.23	0.091	0.157	0.293
Discontinuation: Stage 4	0.024	0.021	0.008	0.032

TABLE 2 Univariate Comparison of Mean Patenting Activity around the JOBS Act

This table reports the univariate tests of innovative activity averaged across sample firms over the two-year period before (Pre-IPO) and the two years after going public (Post-IPO). Variable definitions are provided in Appendix A.

	Pre-JOBS IPOs	Post-JOBS IPOs	p-value of difference
# of Patents: Pre-IPO	8.98	10.90	0.2
# of Patents: Post-IPO	11.35	15.35	0.062
# of Breakthrough Patents: Pre-IPO	2.31	2.68	0.498
# of Breakthrough Patents: Post-IPO	2.42	3.43	0.119
# of Adj. Citations: Pre-IPO	1.67	1.37	0.309
# of Adj. Citations: Post-IPO	1.15	1.34	0.19
# of Claims (Scope): Pre-IPO	0.87	0.90	0.436
# of Claims (Scope): Post-IPO	0.81	0.91	0.001
Market Value of Patents Post-IPO in $mil	5.418	17.105	0.000
Market Value of Patents Post-IPO as % of market value of equity at IPO	1.43	5.63	0.001
R&D spending/assets: Post-IPO	1.36	1.91	0.05
Observations	365	381	

TABLE 3 JOBS Act, Product Life Cycle, and IPO Proceeds and R&D

This table presents OLS regressions of the natural log of the amount of capital raised in the IPO (*Proceeds*) and total spending on R&D over the two years following the IPO, both scaled by the pre-IPO book assets. All independent variables are determined at the time of the IPO. See Appendix A for the variable definition. Standard errors are corrected for clustering of observations at the calendar year level and shown in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

VARIABLES	(1) Proceeds/ Assets	(2) Proceeds/ Assets	(3) R&D/ Assets	(4) R&D/ Assets
POST-JOBS x Early Product Stage	2.720***	2.867***	1.012**	1.119**
	[0.560]	[0.589]	[0.452]	[0.454]
POST-JOBS (1/0)	-0.878***		-0.156	
	[0.195]		[0.159]	
Early Product Stage	-1.553***	-1.606***	2.864***	2.743***
	[0.430]	[0.437]	[0.405]	[0.379]
Log Assets	-0.929***	-0.952***	-0.400***	-0.405***
	[0.055]	[0.056]	[0.066]	[0.068]
Oper.Income/assets	-0.543***	-0.519***	-0.733***	-0.739***
	[0.096]	[0.096]	[0.123]	[0.124]
Book Debt/assets	0.411***	0.391***	0.191	0.180
	[0.134]	[0.123]	[0.124]	[0.124]
Venture backed (1/0)	-0.136	-0.185	-0.115	-0.142
	[0.116]	[0.124]	[0.103]	[0.102]
IPO Underpricing	0.907***	0.900***	0.018	0.009
	[0.172]	[0.163]	[0.139]	[0.149]
Underwriter ranking	0.249***	0.252***	0.160***	0.165***
	[0.020]	[0.020]	[0.040]	[0.041]
Market Return	0.189	0.505	0.587**	0.702***
	[0.388]	[0.300]	[0.263]	[0.238]
Industry market to book	-0.075	0.462	-0.473**	0.153
	[0.209]	[0.408]	[0.168]	[0.315]
Observations	746	746	746	746
Adjusted R-squared	0.636	0.639	0.505	0.509
Year FE	NO	Yes	NO	YES
Industry FE	YES	YES	YES	YES

Table 4 JOBS Act and Patenting Activity in the Post-IPO Period

This table presents regression estimates of the post-IPO patent activity for innovative IPOs in the period 2003-2018. The dependent variable is the count of patents that the firm applies for within two years after going public. Columns 1 through 3 use the natural log (+1) transformation of patent counts, Column 4 uses the raw patent count, and Column 5 uses patent counts scaled by pre-IPO assets. All independent variables are determined at the time of the IPO. See Appendix A for the variable definition. Standard errors are corrected for clustering of observations at the calendar year level and shown in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

VARIABLES	(1)	(2)	(3)	(4) Poisson	(5)
POST-JOBS x Early Product Stage		-0.786**	-0.813**	-3.355**	-0.142**
		[0.327]	[0.331]	(0.821)	[0.067]
POST-JOBS (1/0)	0.219**	0.437***			
	[0.100]	[0.118]			
Early Product Stage		0.887**	0.898**	3.180**	0.179*
		[0.321]	[0.366]	(1.067)	[0.101]
Pre-IPO Innovation			0.802***	0.018**	0.115**
			[0.026]	(0.003)	[0.051]
Log Assets	0.287***	0.178***	0.187***	0.267	-0.080***
	[0.072]	[0.043]	[0.044]	(0.074)**	[0.017]
Oper.Income/assets	0.019	0.010	0.004	0.070	0.013
	[0.035]	[0.030]	[0.030]	(0.071)	[0.020]
Book Debt/assets	-0.095	-0.041	-0.062	-0.132	0.017
	[0.089]	[0.059]	[0.063]	(0.194)	[0.031]
IPO Proceeds/assets	0.050	0.034	0.039	0.104	0.025*
	[0.034]	[0.029]	[0.029]	(0.048)*	[0.013]
Venture-backed (1/0)	0.356***	0.027	0.007	0.144	0.042
	[0.114]	[0.089]	[0.079]	(0.111)	[0.033]
IPO Underpricing	0.359*	0.304*	0.218	0.427	-0.029
	[0.176]	[0.147]	[0.175]	(0.353)	[0.055]
Underwriter ranking	0.007	-0.036	-0.039	0.034	-0.027*
	[0.043]	[0.026]	[0.025]	(0.051)	[0.014]
Market Return	0.136	-0.309	-0.227	0.118	-0.092
	[0.478]	[0.341]	[0.423]	(0.810)	[0.085]
Industry market to book	-0.40***	-0.215	-0.448	-0.684	-0.055
	[0.107]	[0.164]	[0.279]	(0.425)	[0.045]
Observations	746	746	746	746	746
Adjusted R-squared	0.150	0.640	0.649	0.616	0.385
Year FE	NO	NO	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES

Table 5 Test of Parallel Trends before the JOBS Act

This table presents OLS regression estimates of the post-IPO patent activity for innovative IPOs in the period 2003-2018. The dependent variable is the natural log of the number of patents that the firm applies for within two years after going public. All independent variables are determined at the time of the IPO. See Appendix A for the variable definition. Standard errors are corrected for clustering of observations at the calendar year level and shown in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

VARIABLES	(1) Parallel Trend Test	(2) Placebo Test
Time Trend x Early Product Stage	0.140	
	[0.122]	
Time trend	-0.001	
	[0.035]	
Post-Placebo x Early Product		0.370
		[0.741]
Post-Placebo date		0.120
		[0.226]
Early Product Stage	0.074	0.633
	[0.657]	[0.416]
Pre-IPO Innovation	0.859***	0.851***
	[0.034]	[0.032]
Log Assets	0.122*	0.141*
	[0.060]	[0.068]
Oper.Income/assets	0.013	0.009
	[0.077]	[0.076]
Book Debt/assets	-0.112	-0.066
	[0.083]	[0.095]
IPO Proceeds/assets	-0.004	0.002
	[0.043]	[0.045]
Venture-backed (1/0)	-0.000	0.050
	[0.131]	[0.148]
IPO Underpricing	-0.063	-0.064
	[0.321]	[0.321]
Underwriter ranking	-0.005	-0.006
	[0.041]	[0.043]
Market Return	0.130	0.099
	[0.320]	[0.262]
Industry market to book	-0.325	-0.520
	[0.240]	[0.329]
Observations	365	365
Adjusted R-squared	0.667	0.661
Industry FE	YES	YES

Table 6 JOBS Act and Post-IPO Technological Quality of Innovation

This table presents regression estimates of the technological quality of patents applied for by the sample firm within two years after IPO. The dependent variable is the number of adjusted citations per patent in Columns 1 and 2, the number of breakthrough innovations (patents in the 10% of citations) in Columns 3 and 4, and firm-average patent scope (# of independent claims) in Columns 5 and 6. We use the natural log (+1) transformation of these variables. All independent variables are determined at the time of the IPO. See Appendix A for the variable definition. Standard errors are corrected for clustering of observations at the calendar quarter level and shown in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

VARIABLES	(1) Citations	(2) Citations	(3) Breakthrough	(4) Breakthrough	(5) Scope	(6) Scope
POST-JOBSxEarly Product Stage	-0.459**	-0.499**	-0.667**	-0.723**	-0.064	-0.069
	[0.201]	[0.207]	[0.281]	[0.276]	[0.044]	[0.046]
POST-JOBS (1/0)	0.306**		0.210*		0.036	
	[0.125]		[0.113]		[0.062]	
Early Product Stage	-0.148	-0.127	0.789**	0.868**	0.079	0.006
	[0.291]	[0.271]	[0.312]	[0.308]	[0.110]	[0.113]
Pre-IPO Innovation	0.131***	0.129***	0.759***	0.756***	0.278***	0.27***
	[0.011]	[0.011]	[0.026]	[0.026]	[0.053]	[0.051]
Log Assets	0.048	0.045	0.106***	0.122***	0.017	0.026
	[0.034]	[0.030]	[0.035]	[0.031]	[0.017]	[0.016]
Oper.Income/assets	-0.030	-0.028	0.004	-0.000	0.006	-0.003
	[0.022]	[0.021]	[0.028]	[0.029]	[0.010]	[0.012]
Book Debt/assets	-0.003	-0.013	-0.007	-0.020	-0.024	-0.029
	[0.030]	[0.030]	[0.049]	[0.048]	[0.025]	[0.023]
IPO Proceeds/assets	0.017	0.020	0.052**	0.057**	-0.003	-0.001
	[0.016]	[0.015]	[0.020]	[0.020]	[0.009]	[0.009]
Venture backed (1/0)	0.032	0.026	0.096*	0.086	-0.013	-0.023
	[0.049]	[0.053]	[0.052]	[0.052]	[0.031]	[0.029]
IPO Underpricing	0.114	0.129	0.217*	0.229*	0.011	0.007
	[0.081]	[0.077]	[0.122]	[0.114]	[0.037]	[0.042]
Underwriter ranking	-0.008	-0.008	-0.035	-0.039	0.007	0.002
	[0.021]	[0.020]	[0.024]	[0.023]	[0.011]	[0.011]
Market Return	-0.267	-0.033	-0.157	-0.167	0.029	-0.003
	[0.208]	[0.250]	[0.272]	[0.370]	[0.091]	[0.121]
Industry market to book	0.058	-0.013	-0.161	-0.200	-0.063	-0.095
	[0.101]	[0.182]	[0.104]	[0.233]	[0.046]	[0.093]
Observations	746	746	746	746	746	746
Adjusted R-squared	0.259	0.273	0.599	0.603	0.130	0.149
Year FE	NO	YES	NO	YES	NO	YES
Industry FE	YES	YES	YES	YES	YES	YES

Table 7 JOBS Act, Product Life Cycle, and Patent Market Value

This table presents regression estimates of the firm-average market value of patents generated by sample firms within two years after going public. All independent variables determined at the time of the IPO. See Appendix A for the variable definition. Standard errors are corrected for clustering of observations at the calendar quarter level and shown in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

VARIABLES	(1) Patent value/IPO equity value	(2) Patent value/IPO equity value	(3) Ln(Patent value)	(4) Ln(Patent value)
POST-JOBS x Early Product Stage	-0.727**	-0.722**	-0.835**	-0.844**
	[0.334]	[0.320]	[0.388]	[0.381]
POST-JOBS (1/0)	0.654***		0.751***	
	[0.200]		[0.270]	
Early Product Stage	0.858***	0.798***	1.229***	1.160***
	[0.261]	[0.281]	[0.355]	[0.378]
Pre-IPO Citation Count	0.000	0.000	0.000**	0.000***
	[0.000]	[0.000]	[0.000]	[0.000]
Log Assets	0.033	0.034	0.365***	0.378***
	[0.042]	[0.050]	[0.062]	[0.073]
Oper.Income/assets	-0.042	-0.046	-0.081	-0.091
	[0.047]	[0.052]	[0.054]	[0.061]
Book Debt/assets	-0.101	-0.115	-0.166*	-0.185*
	[0.068]	[0.084]	[0.088]	[0.104]
IPO Proceeds/assets	0.010	0.013	0.094***	0.097**
	[0.026]	[0.026]	[0.034]	[0.038]
Venture backed (1/0)	0.011	0.018	0.173	0.172
	[0.104]	[0.110]	[0.133]	[0.129]
IPO Underpricing	0.216	0.218	1.199***	1.180***
	[0.148]	[0.138]	[0.204]	[0.203]
Underwriter ranking	0.009	0.011	0.050	0.047
	[0.031]	[0.035]	[0.037]	[0.041]
Market Return	-0.200	-0.199	-0.264	-0.400
	[0.288]	[0.271]	[0.416]	[0.406]
Industry market to book	-0.083	-0.168	-0.274	-0.234
	[0.140]	[0.347]	[0.193]	[0.551]
Observations	746	746	746	746
Adjusted R-squared	0.055	0.065	0.225	0.228
Year FE	NO	YES	NO	YES
Industry FE	YES	YES	YES	YES

Table 8 JOBS Act, Product Life Cycle and Acquisitions of External Patents

This table presents estimates from OLS of the natural log (+1)of the number of external patents acquired by newly public firms through acquisitions within two years after their IPO. All independent variables are determined at the time of the IPO. See Appendix A for the variable definition. Standard errors are corrected for clustering of observations at the calendar quarter level and shown in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

VARIABLES	(1)	(2)
POST-JOBS x Early Product Stage	-0.235**	-0.259**
	[0.101]	[0.114]
POST-JOBS (1/0)	0.479**	
	[0.168]	
Early Product Stage	-0.379*	-0.391*
	[0.195]	[0.201]
Log Assets	0.524**	0.487***
	[0.168]	[0.164]
Oper.Income/assets	0.029	0.025
	[0.051]	[0.057]
Book Debt/assets	0.020	0.016
	[0.069]	[0.069]
IPO Proceeds/assets	0.125**	0.120**
	[0.051]	[0.047]
Venture-backed (1/0)	0.036	0.008
	[0.153]	[0.161]
IPO Underpricing	0.681**	0.732**
	[0.313]	[0.308]
Underwriter ranking	-0.171**	-0.169**
	[0.065]	[0.061]
Market Return	-0.330	-0.485
	[0.574]	[0.624]
Industry market to book	-0.340	-0.326
	[0.221]	[0.307]
Observations	746	746
Adjusted R-squared	0.140	0.150
Year FE	NO	YES
Industry FE	YES	YES

Table 9 JOBS Act, Product Life Cycle and IPO Failure

This table presents estimates from logistic regressions of IPO failure incidences. The dependent variable is the indicator variable that equals one if the firm is delisted from the exchange by the end of three or five years after the IPO for poor performance reasons. The reported coefficients are odd ratios. All independent variables are determined at the time of the IPO. See Appendix A for the variable definition. Standard errors are corrected for clustering of observations at the calendar quarter level and shown in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

	(1)	(2)	(3)	(4)
	Failed:	Failed:	Failed:	Failed:
VARIABLES	3 years	3 years	5 years	5 years
POST-JOBS x Early Product Stage	5.671**	5.388**	6.803***	6.222***
	[2.807]	[4.126]	[1.468]	[1.369]
POST-JOBS (1/0)	-5.624***		-6.597***	
	[1.855]		[1.210]	
Early Product Stage	-0.673	-0.427	-0.966	-0.921
	[2.034]	[2.535]	[1.839]	[1.909]
Pre-IPO Innovation	0.258	0.178	-0.003	-0.033
	[0.309]	[0.474]	[0.197]	[0.200]
Log Assets	-0.006	-0.046	0.045	-0.060
	[0.581]	[0.951]	[0.187]	[0.213]
Oper.Income/assets	-0.118	-0.089	0.029	0.056
	[0.258]	[0.306]	[0.129]	[0.134]
Book Debt/assets	-0.995***	-1.374*	0.153	0.292
	[0.367]	[0.731]	[0.333]	[0.361]
IPO Proceeds/assets	0.171	0.227	0.009	-0.041
	[0.243]	[0.366]	[0.123]	[0.135]
Venture backed (1/0)	0.912	1.742	0.786	0.923
	[1.266]	[1.884]	[0.639]	[0.646]
IPO Underpricing	-1.103	-1.930	-0.712	-1.062
	[1.937]	[3.229]	[1.443]	[1.481]
Underwriter ranking	-0.427**	-0.466	-0.249***	-0.237***
	[0.166]	[0.284]	[0.077]	[0.085]
Market Return	5.575**	3.608	1.456	2.108
	[2.215]	[3.379]	[1.043]	[1.525]
Industry market to book	-0.307	15.464	-0.357	-1.754
	[0.959]	[9.483]	[0.488]	[1.481]
Observations	729	723	726	720
Year FE	NO	YES	NO	YES
Industry FE	YES	YES	YES	YES