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Policy Uncertainty and Innovation: Evidence from Initial Public Offering Interventions in China

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Abstract. Public equity is an important source of risk capital, especially in China. The Chinese government has occasionally suspended IPOs, exposing firms already approved to IPO to indeterminate listing delays. The temporary bar on going public increases uncertainty about access to public markets for affected firms. We show that suspension-induced delay reduces corporate innovation activity both during the delay and for years after listing. Negative effects on tangible investment and positive effects on leverage are temporary, consistent with financial constraints during the suspensions being resolved after listing. Our results suggest that predictable, well-functioning IPO markets are important for firm value creation. They demonstrate that corporate innovation is cumulative and is negatively affected by policy uncertainty.

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1. Introduction

This paper studies the impact on innovation of a government policy that created uncertainty by suspending IPO activity indefinitely. Specifically, the policy temporarily prevented certain firms that had already been approved to go public from accessing public markets through IPOs. This unique situation offers an ideal setting to explore the impact of policy uncertainty, which is typically difficult to isolate in empirical analysis. In our context, we can contemporaneously compare firms facing policy uncertainty, which lose access to public markets for an indefinite period of time but ultimately go public, with very similar firms that have only short periods of normal processing time between their IPO approval and listing. The forced, uncertain suspension-induced delay reduces innovation, which we measure using patenting activity. The decline in innovation endures after listing, suggesting that innovation has a cumulative dimension and that temporary suspensions could have a persistent impact by altering manager preferences.

The literature has established that when firms intending to IPO face strategic incentives to remain private, staying private improves innovation quality (Ferreira et al. 2012, Bernstein 2015). At the same time, other studies find that public equity enables innovation by providing risk capital (Atanassov et al. 2007, Acharya and Xu 2017). We shed light on an as-yet unstudied dimension: certainty in access to public markets. This is especially relevant in emerging economies, where alternative sources of risk capital are less mature and regulatory infrastructure is less predictable than in developed countries (Rajan and Zingales 2001, Ahlstrom et al. 2007, Hsu et al. 2014, Cong et al. 2020b). No emerging financial market is more important than China's (Allen et al. 2008).

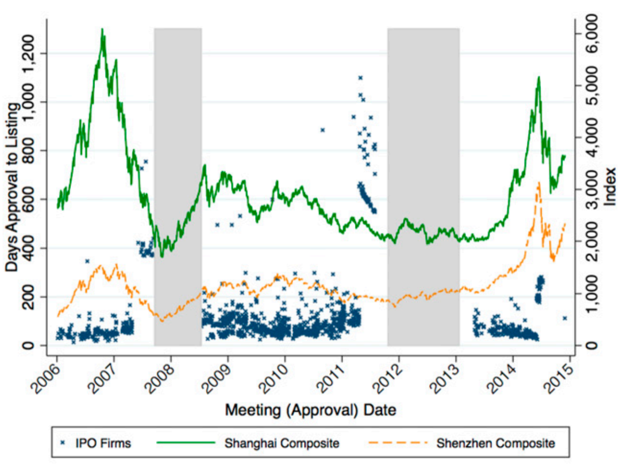
We exploit a novel source of variation offered by the Chinese setting: Regulators have on multiple occasions suspended all IPO activities. Although related to the state of the market, the suspensions were not scheduled and were not anticipated multiple months in advance. The suspensions generate plausibly exogenous listing delay among firms already approved to go public because firms have little ability to time the IPO market. IPO approval takes two to three years in normal, nonsuspension times. Once approved, firms take several months to complete the final steps. As a result of this multiyear time frame from application to listing, aggregate market conditions do not affect the order of firms listing around suspension announcements.

Although normal, predictable time between approval and listing may create financial constraints, suspension-induced delay adds the element of uncertainty in addition to further delay.

In analysis, we focus on a sample of firms that Chinese regulators approve to IPO in the 12 months before a suspension announcement for two suspensions, the first from September 2008 to July 2009 and the second from October 2012 to January 2014. All of these firms ultimately go public on Chinese exchanges; but depending on their approval dates, some experience sharply greater listing delays induced by the suspensions (see Figure 1). Members of the control group are approved earlier and list with normal delay (i.e., standard processing time), whereas members of the "treated" group must wait until the suspension ends and face a longer time between approval and listing as well as greater uncertainty about when they can list. No firms in our sample choose to withdraw and list abroad.[1] In a key placebo test, we show that variation in normal delay due to processing time—which contains no policy uncertainty—operates very differently from suspension-induced delay; it has no effect on innovation. This helps to demonstrate the importance of policy uncertainty independently of any financial constraint effect.

Firms in the control and treatment groups are similar before approval, and we verify that the order of listing closely follows the order of IPO approval. As we explain in Section 4.1, if any queue-jumping occurs after approval it does not adversely bias our estimation because we define treatment by the date of approval, which occurs before a suspension announcement. If queue-jumping occurs before approval, it should affect treatment and control equally. Suspension-induced delay is therefore plausibly exogenous to firm-specific factors, so it offers quasi-experimental variation in timely access to public capital.

Figure 1. (Color online) IPO Delay and Shanghai and Shenzhen Composite Indices



Notes. This figure shows the delay (days between IPO approval and listing) for all IPO firms (outlier firms are excluded). Each IPO firm is a point. It also shows as lines the Shanghai and Shenzhen composite indices daily close (SHCOMP:IND and SZCOMP:IND in Bloomberg, respectively). The year labels indicate the end of each calendar year. The shaded areas correspond to the suspensions.

We estimate the effect of suspension-induced delay in regressions that control for the listing date and firm variables, such as state ownership, size, age, and industry. To measure innovation effort, we use the number of patent applications to China's State Intellectual Property Office (Chinese patent applications), granted Chinese patents, citations to Chinese patents, and granted global (non-Chinese) patents.[2] In the year after IPO approval, treated firms, which have on average 16 months of suspension-induced delay, have 28% fewer Chinese patent applications than control firms, which have on average three months of normal delay. The negative effect on treated firms is significant and persists over time. For example, in the fourth year after the approval year, when all firms are public, the treated group still has 18% fewer patent applications. Suspension-induced delay also reduces patent quality; in the year after IPO approval, granted Chinese patents, citations to Chinese patents, and granted global (non-Chinese) patents all decline. Suspension-induced delay further leads to higher leverage, lower return on sales, and lower investment in tangible assets in the year following IPO approval. However, none of these non-innovation effects endure after listing.

Our identification assumptions do not require suspensions to be independent of aggregate economic conditions. Instead, we show that cross-sectionally, firms do less innovation when they experience suspension-induced delay. For example, one specification considers the first and second years after IPO among treated firms and aligns control firms so that they are considered in the same calendar time as the treatment firms. We further show that our main results are robust to instrumenting for suspension-induced delay with the approval date and disappear in sensible placebo tests.

We focus on two non-mutually-exclusive channels that the literature has highlighted in order to explain our findings: capital constraints and policy uncertainty.[3] Financial constraints are known to impede investment (Froot et al.1993, Dixit and Pindyck 1994, Almeida and Campello 2007). In the year following IPO approval, when treated firms are still private but their nondelayed counterparts have listed, the effects on leverage, tangible investment, and innovation are consistent with a shock to access to capital. This relationship between financial constraints during suspension-induced delay and innovation is intuitive and complements Brown et al. (2009) and Acharya and Xu (2017). Furthermore, this evidence of financial constraints suggests that, in China, IPO markets are important for capital provision.

However, financial constraints do not tell the whole story. We find evidence that policy uncertainty (indefinitely long IPO suspensions) is an important channel to explain the negative effect on innovation. Consistent with the real options literature, which predicts that uncertainty negatively affects irreversible investment (Dixit and Pindyck 1994), suspension-induced delay reduces tangible investment and innovation activity. Although these results could also reflect financial constraints, several findings are inconsistent with them being the main mechanism. First, they predict that firms with better access to alternative sources of capital in the form of debt or venture capital/private equity (VC/PE) will be less affected. Yet state-owned enterprises (SOEs)—which have advantaged access to credit—are no less affected than private firms. Firms with prior VC/PE financing are more affected, which could reflect their higher inherent risk under uncertainty. Furthermore, we do not find that firms expected to be more financially constrained based on standard measures experience larger effects. To corroborate our argument that the suspensions increased general uncertainty, we document that the suspensions were associated with lower VC investment in China after controlling for market conditions, even among VC firms based in the United States and active in China. In sum, the evidence strongly supports an important role for policy uncertainty.

Policy uncertainty (and financial constraints) affect innovation not only during the suspensions but also long after the uncertainty (or constraint) is resolved and the firms publicly list. This may reflect the cumulative nature of innovation. Another way for suspensions to affect long-term innovation is that they may change manager preferences, especially their tolerance for failure and interest in experimentation (Manso 2011, Tian and Wang 2014). Using data on manager and CEO changes, we find evidence that managers with experience of suspension-induced delays innovate less, consistent with the channel of uncertainty reducing tolerance for failure or interest in experimentation in the long run.

The remainder of the paper proceeds as follows. Section 2 describes institutional background and our paper's contributions to the literature. Section 3 introduces the empirical strategies and the data. Section 4 presents the findings. Section 5 discusses economic mechanisms and potential channels. Section 6 concludes.

2. Literature and Institutional Background

In this section, we describe how our paper contributes to existing studies, followed by a brief introduction of China's public equity markets and the IPO process. Then we explain the IPO suspensions we use to identify the effect of suspension-induced delay.

2.1. Contributions to the Literature

To our knowledge, this paper is the first to explore how regulatory uncertainty about access to capital affects corporate innovation. This adds to our understanding of the institutional frictions that hamper innovation, which are more severe in developing countries without strong contract enforcement (Aghion and Tirole 1994, Lerner and Schoar 2005). Uncertainty is also central to how our setting differs from the literature comparing public and private firms. There is a large literature at the macroeconomic level about the effects of policy uncertainty on the economy. Friedman (1968), Rodrik (1991), and Hassett and Metcalf (1999), among others, consider the detrimental economic effects of monetary, fiscal, and regulatory policy uncertainty. Bernanke (1983) argues that high uncertainty delays investment, which is costly to reverse. Bond and Goldstein (2015) and Baker et al. (2016) show that macropolicy uncertainty negatively affects firms and financial markets. In corporate finance, Bonaime et al. (2018) show that political and regulatory uncertainty are negatively associated with merger and acquisition activity. Others document how policy uncertainty reduces corporate investments in tangible assets, including by inducing precautionary delays because of investment irreversibility (e.g., Bloom et al. 2007, Julio and Yook 2012, An et al. 2016, Jens 2017). In the Chinese context, Brunnermeier et al. (2020) point out that an interventionist approach can create uncertainty for firms, affecting corporate decisions. Although most studies use political/election uncertainty or news-based text measures, we contribute by utilizing a quasi-natural experiment concerning regulatory uncertainty.

No study to date analyzes the effect of policy uncertainty on innovation and the long-term impacts of transitory policy uncertainty shocks. Although Gulen and Ion (2015) show that policy uncertainty can depress corporate investment by inducing precautionary delays of investment, Julio and Yook (2012) and Stokey (2016) document that investment immediately bounces back after uncertainty is resolved. Innovation investment is different from investment in tangible assets because it is riskier, imperfectly contractible, has long time horizons, and has a cumulative dimension. Perhaps the closest study to ours is Bhattacharya et al. (2017), which finds that innovation activities drop significantly during times of political election uncertainty. They focus on a distinction between policy and political uncertainty. We contribute by studying financial market policy uncertainty and using a source of variation that occurs only once in a firm's lifetime (as firms only IPO once).

We also contribute to work on the relationship between going public and firm behavior. In addition to innovation, researchers have addressed investment (Pagano et al. 1998, Asker et al. 2014, Gilje and Taillard 2016), the private benefits of control (Doidge et al. 2009b), profitability (Pástor et al. 2009), and product markets (Chemmanur et al. 2009). A second strand studies the effects of government interventions in financial markets (Cong et al. 2019). Although government intervention in IPO markets is common in developing economies, relatively little is known about the effects of these interventions.[4] A third strand of research examines China's IPO process, including Tian (2011), Allen et al. (2019), Lee et al. (2017), and Shi et al. (2018).

Although the IPO suspension policy itself is China specific, policy uncertainty in IPO markets exists in many countries. Chinese stock markets were modeled after those in developed countries in some fundamental ways and have been shown to price future profits as informatively (Carpenter and Whitelaw 2017, Carpenter et al. 2020). Furthermore, since the early 2000s, Chinese private equity and patenting activity have borne increasing similarity to the United States and Europe (e.g., Guo and Jiang 2013, Fang et al. 2017). Therefore, our findings offer insights and implications that are relevant beyond the Chinese context. External validity aside, we also believe that the results are inherently important as China is the second largest and one of the fastest growing economies in the world.

Our results support the importance of market-based mechanisms for Chinese firms' productivity growth (Aghion et al. 2015 and Fang et al. 2017). We do not address the welfare effects of the IPO suspensions; but our findings suggest that promoting innovation may be one reason for Chinese regulators to prioritize predictable, well-functioning IPO markets going forward.[5] Understanding how Chinese market interventions affect domestic innovation is important not only because the government plays an especially active role in financial markets but also because corporate innovation is central to China's ongoing effort to transition from export- and infrastructure-led growth to an economy centered around high-tech industries and consumption.[6]

2.2. The IPO Process in China

China's banking sector, traditionally the main source of capital for Chinese firms, is not especially well-suited to fund risky projects (Atanassov et al. 2007) and typically favors less-innovative SOEs (e.g., Cong et al. 2020a). Over time, it is slowly giving way to more risk-friendly public and private equity finance (Allen et al. 2019). In the decade after China established the Shanghai Stock Exchange (SSE) and the Shenzhen Stock Exchange (SZSE) in 1990, domestic public markets primarily served SOEs (Fan et al. 2007; see Carpenter et al. 2020 for a review). China's public markets have recently grown dramatically and now serve private enterprises as well as SOEs. The Chinese A share market is the second largest in the world, with about 3,000 firms listed and a total market capitalization of more than $8.2 trillion USD at the end of 2017. Domestic listings are primarily on the "main board" and "SME board" at SSE and SZSE. There are also newer, smaller boards targeting younger firms (e.g., ChiNext or NEEQ) that have less stringent listing criteria but are fairly illiquid and often over the counter (OTC). As IPOs recede in importance in the United States, they are growing in importance in China. In 2017, there were 438 IPOs on the SSE and SZSE, compared with a total of 160 in the United States.[7]

A firm seeking to conduct its IPO in China's domestic markets must navigate an elaborate process administered by the China Securities Regulatory Commission (CSRC). This administrative approval-based system contrasts with the disclosure-centric, registration-based system in the United States. There are four major steps. First, the firm hires financial professionals, such as investment bankers and accountants, for "tutorship," restructuring the firm into a qualified stock share limited company and preparing the financial and compliance documents. Preparation and actual restructuring take one to three years.[8] Second, the firm and underwriter submit an application to the CSRC. Firms applying to IPO form a queue based on the order of application. According to the WIND commercial database, in late 2016 there were 726 firms in the queue. The CSRC has published the numbers of candidates waiting for approval and of those approved recently.[9] Because it takes multiple years for an application to be approved, firms cannot time their listing as they do in the United States. They typically apply as soon as they meet the requirements.

Third, the Stock Issuance Examination and Verification Committee (the "committee") of the CSRC determines whether the applicant meets the regulator's listing criteria, which seek to ensure that only "healthy" firms gain access to the equity markets and include stringent historical financial performance requirements.[10] The committee reviews the application documents and decides whether to approve the listing.[11] The criteria beyond the official performance requirements that the CSRC uses to select candidates are not public. This stage takes three to six months on average, because the committee often meets multiple times and requires the applicants to address numerous issues before granting the final approval. The committee typically rejects 20%–30% of IPO applications, though the rate varies over time.[12]

In the fourth step, after the committee grants formal approval, the firm may apply to list at one of the domestic exchanges within six months. To do so, they solicit information from institutional investors, choose an exchange, and then build the book, all with the help from underwriters. The chosen stock exchange reviews the application to ascertain compliance with exchange rules—a procedure known to be a rubber stamp because exchange rules mirror CSRC requirements. Once approved, the firm can conduct its road show and decide on a share subscription day. The issuer then publishes the prospectus in designated newspapers at least three days before the subscription day and announces the issue at least one day prior to the subscription day. Finally, it takes an average of 24 working days after the subscription day for the shares to publicly list (Shi et al. 2018 contains more details). The interval between approval and listing is two to five months (the average is three), except during IPO suspensions. Approved firms try to list as soon as possible because after six months, they must renew approval. Very rarely do firms and the CSRC delay listing because of disagreements on share prices.

2.3. IPO Suspensions

The CSRC is concerned that too many IPOs will reduce liquidity, depress overall market prices, or adversely affect incumbent public firms because the cap (currently about 23) on the price to earnings ratio for IPOs might draw capital from incumbent to newly listed stocks (e.g., Braun and Larrain 2008, Tian 2011, and Packer et al. 2016). As an extreme form of regulating the IPO market, the CSRC occasionally suspends all IPO activities beyond the application submission step. Between 1994 and 2016, there have been nine IPO suspensions.[13] The suspensions exogenously imposed uncertain periods of delay on firms that were approved to IPO shortly before the suspensions were announced. We expect that suspension-induced delay may be costly to firms if the delay imposes capital constraints; the firm would then have to forego strategic opportunities—such as acquisitions or large investments—and long-term planning would be disrupted (Shi et al. 2018). We also expect that the suspensions may have increased market uncertainty about the firm, which is costly (e.g., Almeida et al. 2011 and Wang and Zhu 2013). Both of these potential negative effects of the suspensions are widely recognized in Chinese and foreign media and among practitioners.[14]

The suspensions all started and ended without preannouncements. Although the fact of historical suspensions means that market participants know a suspension is possible, the suspensions are not predictable weeks in advance.[15] For example, after October 19, 2012, the CSRC ceased holding weekly review meetings, with no initial public explanation. The financial press initially expected the suspension to be short, but instead it lasted more than a year. More generally, the suspensions are predicated on the CSRC's concern for "market stability," not on individual firms' characteristics.[16] Firms likely form some expectations of the probability of a suspension. Our empirical strategy focuses on firms that should have similar levels of anticipation and preparation.

In sum, three institutional features make China an ideal setting to study uncertainty in access to public markets: (1) the process is sufficiently long that firms applying to IPO cannot accurately foresee future market conditions or suspensions at the time they will list (Guo and Zhang 2012); (2) once an application is approved, firms all go through a standard procedure to list with delay determined by the CSRC's suspension decisions; and (3) there is a substantial cohort of approved firms waiting to list at any given time, which are negatively shocked by the suspensions

3. Empirical Strategy and Data Description

This section explains how we use the IPO suspensions to identify the effects of uncertain suspension-induced delay on firm outcomes.

3.1. Approach

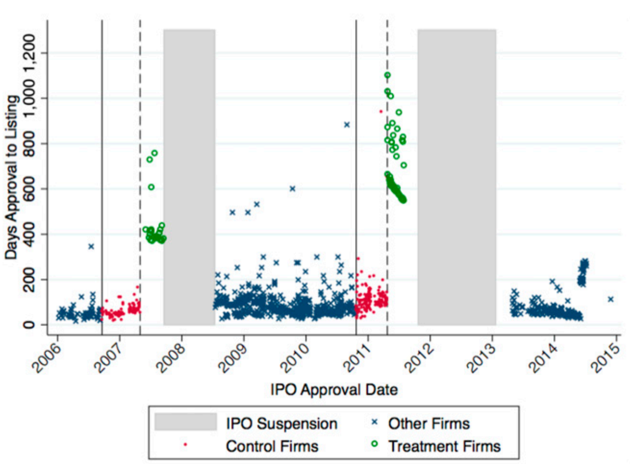
We are interested in the effects of IPO-suspension-induced delay between approval and listing on firm outcomes. In the absence of a suspension, the interval from approval to listing is 3.3 months.[17] However, it is possible that both the approval decision and the exact timing of listing conditional on approval may reflect firm-specific unobservables that could confound our estimates. Therefore, we do not use raw delay as our independent variable of interest except in robustness tests.

Instead, our approach exploits the fact that the approval date is highly predictive of whether a firm was forced to delay until after the suspension ended. In a naive instrumentation approach, we divide our estimation sample into treatment and control groups based only on the approval date. First, we define the estimation sample as firms approved in the 12 months before each of the two suspensions were announced. (The results are not sensitive to this definition and Table A.2 in Online Appendix A shows that firms approved during the 12 months are not observably of lower quality than firms approved at other times.) Figure 2 describes our approach graphically, in which each dot, circle, or cross is an IPO. The approval date is on the horizontal axis and delay between approval and listing is on the vertical axis. The estimation sample comprises the dots and circles to the right of the solid lines and to the left of the suspension periods.

Second, we identify the approval date that lies at the discontinuity where subsequently approved firms were delayed as a result of the suspension. This is represented by the dotted lines in Figure 2. Control firms are the small dots on the left side of the dotted lines. The treatment firms are the circles to the right of the dotted lines. Average delay for the control group is 3.2 months, whereas it is 16.3 months for the treatment group (Table 1). Our results are not sensitive to the precise location of the dotted line. Figure 3 shows the same data but with the listing date on the horizontal axis.[18]

The identification assumption is that firm-specific factors do not drive treatment assignment within the estimation sample. That is, among firms approved near in time to a suspension, delay is not fully predictable and is exogenous to firm characteristics, as we describe in Section 2 and evident from the observable queue post-2012 and t-tests (in Section 3.3 and Table 1). As firms must have applied to IPO three or more years earlier, their positions in the queue should not be related to their expectations of a suspension based on market conditions near in time to the actual suspension. To the degree firms may have anticipated the suspensions, we are examining the effect of suspension-induced delay among firms with similar level of anticipation and preparation.

Figure 2. (Color online) Empirical Design—IPO Approval Date



Notes. This figure shows the delay (days between IPO approval and listing) for all IPO firms (a few outlier firms are excluded). The x-axis is the date of IPO approval. Each IPO firm is a point. The sample used in analysis (estimation sample) are those firms to the right of the solid vertical lines and to the left of the suspension periods. These are firms approved to IPO in the 12 months before the suspension. They are divided into treatment and control groups based on the observable discontinuity in delay. Small dots are control firms, and circles are treated firms. Firms with less than 200 days of delay are excluded. The year labels indicate the end of each calendar year.

As with any quasi-experimental strategy, it is challenging to completely rule out endogeneity in delay. The primary concern is that some firms jump the queue to avoid suspension-induced delay. This should not bias our results because we define treatment by the date of approval, which occurs before a suspension announcement. Moreover, we test in our sample whether actual listing follows the same order of approval and find that the orderings have a correlation of 0.98, which indicates almost no change in the order in the queue from approval to listing.[19] Note that queue-jumping by politically connected or state-owned firms, even if present, should bias our results against finding a detrimental effect of delay because politically connected firms and SOEs are well known to underperform relative to their counterparts along various dimensions (Dollar and Wei 2007, Fan et al. 2007, Chen et al. 2016, and Piotroski and Zhang 2014), including innovation outputs (e.g., Jefferson et al. 2006). If these firms have less delay because they jump the queue, it is even more striking to find that delay leads to underperformance.

A second concern is that firms with unobservably different quality complete the approval-to-listing process faster and so are less likely to be delayed. However, the approval date defines treatment, so this should not affect our estimates. Also, we show in Table A.2 Panel 1 in Online Appendix A that firms in the estimation sample do not take longer to list than those outside the sample; after removing the suspension months, time to listing is very similar (3.16 and 3.36 months). Within the estimation sample, the control group's approval-to-listing interval averages 3.23 months.

A third concern is that regulators decide to launch an IPO suspension based on their assessment that firms approved but not yet listed are of low quality. In addition to institutional evidence that overall market conditions drive suspension decisions (Section 2.2), we show that firms in the estimation sample are similar to firms outside it; if anything, they have higher quality. Table A.2, Panel 2 in Online Appendix A shows that among observables in the year before IPO approval, estimation sample firms are not significantly different, except that they have somewhat higher patenting and earnings.[20]

3.2. Specification

Our primary specification estimates variants of Equation (1), where j denotes a firm and t denotes a year. The coefficient of interest is β on whether the firm is in the treatment group, and thus experiences suspension-induced IPO delay.

$$P_{jt} = \alpha + \beta Treat_j + \delta' \mathrm{V}_{jt} + \gamma Industry_j + Year_{jt}/f \times (ApprovalDate_j) + \varepsilon_{jt} \quad (1)$$

Table 1. *t*-Tests for Differences by Treatment Status

Panel A: Delay (months approval to listing)

	Control		Treatment			
	N	Mean	*N*	Mean	Difference	2-Tailed *p*-value
Delay (months approval to listing)	232	3.23	118	16.3	–13.1	0.00
Mock delay (months approval to listing omitting months during IPO suspensions)	232	3.23	118	3.03	0.20	0.71

Panel B: Outcome variables in year before IPO approval

	Control		Treatment			
	N	Mean	*N*	Mean	Difference	2-Tailed *p*-value
Chinese invention patent applications	232	4.69	118	4.24	0.46	0.70
Granted Chinese invention patents	232	1.98	118	2.04	–0.06	0.94
Citations to Chinese invention patents	232	22.0	118	23.1	–1.08	0.85
Granted global utility patents	232	0.04	118	0.02	0.02	0.35
PPE investment	232	0.15	118	0.14	0.00	0.81
Leverage	232	1.24	116	1.15	0.09	0.57
Revenue	232	1,450	118	1,769	–319	0.53
Return on sales	232	0.19	118	0.19	0.00	0.97
Earnings	232	172	118	158	14	0.27
Discretionary accruals	232	0.000	118	0.014	–0.01	0.21

Notes. This table summarizes *t*-tests for differences of means across treatment and control groups. We show all variables that we observe in the year before IPO approval. The sample is that used in estimation: firms approved to IPO in the 12 months before an IPO suspension. We naively instrument for delay with a treated indicator that is defined by an observed discontinuity in delay. For the 2008–2009 (2012–2014) suspension, it is 1 for firms approved on or after June 5, 2008 (April 24, 2012).

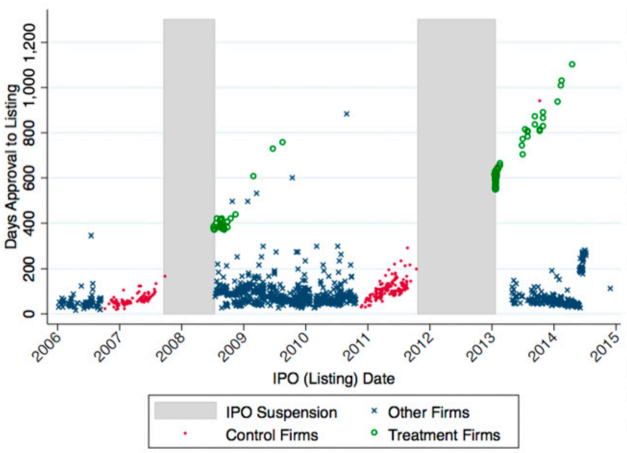
As discussed in Section 3.1, $Treat_j$ is defined as being one of the circle firms to the right of the dotted lines in Figure 2; more formally, these are firms approved to IPO between June 5, 2008, and September 19, 2008 (starting date of the 2008–2009 suspension) and between April 24, 2012 and October 19, 2012 (starting date of 2012–2014 suspension).[21] We control for the year of approval in the primary specification but show that the results are robust to controlling for functions of the particular approval date, which makes the analysis similar to a regression discontinuity design.[22]

Treated firms are predominantly approved but not yet listed by the time the suspension began; as explained above, we define $Treat_j$ using the approval date rather than actual delay to avoid any possibility that our results stem from queue-jumping. Control firms are those approved before these cutoffs but within the 12 months prior to the suspension start (the results are not sensitive to the exact number of months). The primary dependent variable (P_{jt}) is the number of Chinese patent applications in a 12-month period (e.g., the 12 months after IPO approval). We also consider the number of granted Chinese invention patents, citations to granted Chinese patents, and global non-Chinese granted patents. To investigate the general impact of suspension-induced delay, we examine the effects on a diverse array of other outcomes, such as leverage, market share, tangible investment, and earnings.

We include a vector of controls $\mathbf{V}_{jt}$, specifically firm age, revenue, leverage, investment, a fixed effect for the exchange (Shanghai or Shenzhen), and indicators for whether the firm is state owned and whether it previously received PE/VC financing. Following Hsieh and Song (2015), we define a firm as an SOE if either the state owns at least 50% of registered capital or if the state is reported as the controlling shareholder. We also include industry fixed effects (25 industry categories). Finally, we include an indicator for the suspension that occurred within the 12 months after the firm was approved, which is equivalent to controlling for year. We double cluster errors by industry and listing quarter.

We begin by focusing on the year following approval to examine the effect, whereas treated firms are delayed and still private. This approach compares public and private firms, which has been the approach in the literature but conflates the effects of suspension-induced delay and listing. We then examine the longer-term effect of suspension-induced delays. This approach considers firms at a similar stage in their lifecycle, in the sense of being after the

Figure 3. (Color online) Empirical Design—IPO Date



Notes. This figure shows the delay (days between IPO approval and listing) for all IPO firms (a few outlier firms are excluded). The x-axis is the date of IPO (listing). Each IPO firm is a point. The sample used in analysis (estimation sample) are those firms symbolized by small dots or circles. These are firms approved to IPO in the 12 months before the suspension. They are divided into treatment and control groups based on the observable discontinuity in delay. Small dots are control firms, and circles are treated firms. Firms with less than 200 days of delay are excluded. The year labels indicate the end of each calendar year.

watershed IPO event (third year after IPO approval onward for most treated firms). An alternative specification considers the first and second year after IPO for delayed firms and aligns control firms so that they are considered in the same calendar year as the treatment firms.

3.3. Data and Summary Statistics

This paper employs data from many sources. Most crucially, we obtain IPO application and approval data from the China Securities and Regulatory Commission for listings on the A-share Shenzhen and Shanghai exchanges between 2004 and 2015. We hand collect the dates for IPO suspensions from official announcements and news articles. China Securities Market and Accounting Research (CSMAR)/WIND (the Bloomberg equivalents) provides IPO prospectus data, listing, financial data, as well as data on executive mobility (CSMAR Executive Board Database). We supplement this with data from Compustat and SDC New Issues. We obtain annual and monthly invention patent application and grant data from the State Intellectual Property Office (SIPO).[23] We match the firms in our sample to patent and citation data using Google Patents, which includes the entire collection (over 87 million) of granted patents and published patent applications from 17 major patent offices around the world (including U.S. Patent and Trademark Office (USPTO) from 1790, European Patent Office (EPO) and World Intellectual Property Organization (WIPO) from 1978). Finally, VC/PE investment data are from IPO prospectuses and Private Capital Research Institute (PCRI) data, all cross-validated with the ChinaVenture Source and SDC VentureXpert databases.

Table 2, Panels A–F describe data used in our analysis. Panel A summarizes categorical IPO information for all 1,558 firms in the data, which includes all IPOs on the Shanghai and Shenzhen exchanges between 2004 and 2015. We focus on Shanghai and Shenzhen Main and SME Boards for three reasons. First, during our sample period, they represent over 93% of listed firms, 97% of the public market capitalization, and over 90% of all transactions, based on analysis of the WIND database. Second, the additional exchanges are new relative to the IPO suspensions, limiting our ability to observe firms before the suspensions. Third, relative to the boards we examine, the stocks on the additional boards are smaller and much less liquid (Li et al. 2015). The new boards are not comparable to NASDAQ in the United States.

Table 2, Panel B contains continuous IPO data. IPO delay averages 4.3 months in the whole sample, with a standard deviation of 5.8 months. Our estimation sample consists of 350 firms approved to IPO within 12 months before a suspension announcement.[24] Those approved earlier in this time frame were ahead in a queue and listed with little delay, whereas the remainder were forced to wait until the suspension ended. We focus on the two suspensions from September 16, 2008 to July 10, 2009 and from October 19, 2012 to January 16, 2014 (see Table A.1 in Online Appendix A for details about these suspensions) out of a total of five suspensions in the data because (i) the two suspensions in 2004–2006 are only separated by four months and so we cannot construct treatment and control groups; (ii) many financial variables are missing before 2004; and (iii) long-term outcome variables for firms for the last suspension in 2015 are not yet available. Remaining summary statistics focus on the estimation sample. For example, average underpricing (the difference between the closing price on the first trading day and the offer price) in our data are almost 80%, consistent with prior studies.

We use the number of patent applications to reflect innovation effort, though we recognize they also represent the firm effort to codify, disclose, and protect intellectual property (Kortum and Lerner 2001, Rajan 2012). We use only invention patents, which are the analog to utility patents in the United States; they cover new technical solutions relating to a product, a process, or improvement. Invention patent protection lasts 20 years from the application. The patent-based variables are summarized in Table 2, Panels C and D.[25] In the estimation sample, the average firm files five patents in the year following IPO

Table 2. Summary Statistics

Panel A: Categorical IPO data

	N
IPOs in Shanghai/Shenzhen (2004–2015)	1,558
IPOs in Shanghai	290
IPOs in Shenzhen	1,268
State-owned (SOE)	241
Venture backed	634
Private foreign PE/VC director on board	33
State-backed Chinese PE/VC director on board	150
Private Chinese PE/VC director on board	206

Panel B: Continuous IPO data (listing less approval date, months)

	N	Mean	Median	Std Dev	Min	Max
Whole sample						
IPO delay in months (time approval to listing)	1,558	4.3	2.3	5.8	0.43	43.4
Estimation sample†						
IPO delay in months (time approval to listing)	350	7.7	3.7	8.1	0.63	36.63
Market cap at listing	350	3,313	913	15,141	145	22,0000
IPO proceeds	350	1,369	463	5,413	121	66,276
Price-to-book ratio first day of trading	350	12.0	10.2	8.9	1.5	108.3
IPO underpricing††	350	−0.77	−0.8	0.08	−0.88	−0.3

Panel C: Annual patent data in year following IPO approval for estimation sample

	N	Mean	Median	Std Dev	Min	Max
Chinese invention patent applications	350	5.01	3	6.73	0	43
Chinese granted invention patents	350	1.58	1	2.06	0	13
Citations to granted Chinese invention patents	350	23.8	7	46.5	0	616
Granted global (non-Chinese) utility patents	350	0.04	0	0.33	0	5

Panel D: Annual Chinese invention patent applications in later years

	N	Mean	Median	Std Dev	Min	Max
In third year after IPO approval if public	342	5.09	3.5	6.63	0	44
In fourth year after IPO approval if public	320	4.83	3	6.14	0	40
In year after IPO	350	4.24	2	5.59	0	34
In second year after IPO	350	4.85	3	8.79	0	113

Panel E: Corporate data in year following IPO approval for estimation sample

	N	Mean	Median	Std Dev	Min	Max
PPE investment±	350	0.13	0.1	0.11	0	1.12
Leverage±	350	0.76	0.52	0.94	0.03	11.34
Revenue	350	6013	551	48,662	65	840,000
Return on sales	350	0.79	1.07	0.49	0.02	1.52
Earnings‡‡	350	724	72	7,763	5.83	140,000
Discretionary accruals	340	0.07	0.05	0.14	−0.44	0.62

Panel F: Corporate data in year following IPO for estimation sample

	N	Mean	Median	Std Dev	Min	Max
PPE investment±	350	0.13	0.1	0.12	0	1.12
R&D/assets	350	0	0	0.01	0	0.05
R&D expenditure	350	1.45	0	5.65	0	54.4
Leverage±	350	0.54	0.34	0.8	0.01	11.3
Revenue	350	1,244	630	1,691	64.6	13,335
Employees	350	2,516.4	997	6,443.09	63	59,996
Payroll	350	178	61.1	511	5.11	5,504
Market share*	350	2.47	0.37	6.34	0.02	40.3

Table 2. (Continued)

Panel F: Corporate data in year following IPO for estimation sample						
Return on sales	350	1.16	1.13	0.11	1.01	1.58
Earnings‡	350	752	75.4	7,776	5.83	140,000
Cash/assets	346	0.39	0.38	0.19	0.03	0.92
Board size	350	9.23	9	2.09	5	17
Discretionary accruals	340	0.07	0.05	0.14	–0.44	0.62

Notes. This table contains summary statistics about all IPOs on the Shenzhen and Shanghai exchanges between 2004 and 2015. Panel A contains categorical data about the IPOs for the whole sample. Panel B describes continuous IPO data, including the time between IPO approval and listing (delay). Currency-denominated variables are in million Renminbi (RMB) throughout. Panel C contains patent data in year after IPO approval, and Panel D contains patent data in subsequent years. Panel E describes corporate variables in the year after IPO approval (many variables are unavailable until after IPO). Panel F describes corporate variables in the year after IPO. R&D, research and development.

†Estimation sample consists of firms approved to IPO in the year before either 2008–2009 or 2012–2014 suspension.

††IPO underpricing is defined as $\frac{P_c - P_o}{P_o}$, where P_c is the closing price on the first day of trading and P_o is the offer price.

±Investment and leverage calculated as fraction of total assets.

‡Equivalent to net income, in nominal RMB.

*Revenue of firm i in year t scaled by total revenue of industry in year t; industry is CSRC industry (two digits if in manufacturing, one digit otherwise).

approval, and the number only starts to decline after the fourth year after IPO approval conditional on public listing (to 4.8), though not significantly. The sample size declines somewhat because of truncation. In the first and second year after IPO, the average firm files 4.2 and 4.9 patent applications respectively.

We use two measures of patent quality. First, we use Google Patent data for citations of Chinese patents, which to our knowledge is new to the literature measuring innovation among Chinese firms, and include citations to patents filed via the Patent Cooperation Treaty used in Boeing and Mueller (2016) and Rong et al. (2017). The average firm has 23.8 citations to granted patents that were filed in the year following IPO approval. Note that different industries have systematically different citation rates. The industry fixed effects that we include in regressions help to account for these systematic differences; as we are not conducting cross-industry comparisons, the differences should not confound our results. We also control for the truncation of the citation data with time fixed effects. A second measure of patent quality is the number of granted patents, filed in Chinese and foreign (non-Chinese) patent offices, respectively.[26] We term the latter "global" patents. The average firm has 0.04 global granted patents that were filed in the year following IPO approval.

Corporate variables for the year following IPO approval and the year following listing are shown in Table 2, Panels E and F. Leverage, cash and plant, property, and equipment (PPE) investment are scaled by total assets. Market share is a focal firm's share of total industry revenue, where industry is defined using a CSMAR variable with 25 categories. Some variables are not available for pre-IPO years. We also collect data on research and development (R&D) expenditure; however, these data only exist after 2007 and appear to be poor quality. Finally, a routinely used accounting measure for window dressing in both the U.S. and Chinese contexts is the volume of discretionary accruals.[27]

T-tests are informative about ex ante differences between the treatment and control groups. The results are in Table 1. First, treated firms do not take longer to list once suspension delay periods are removed (Panel A); the average control (treatment) firm takes 3.23 (3.03) months to list. Therefore, it is not the case that absent suspensions, the treated group would have taken longer to list anyway. We also examine pre-IPO approval year patenting activity, financial variables, and other firm characteristics in the second year prior to IPO in Panel B. There are no significant differences and no evidence that the treated group is of lower ex ante quality.

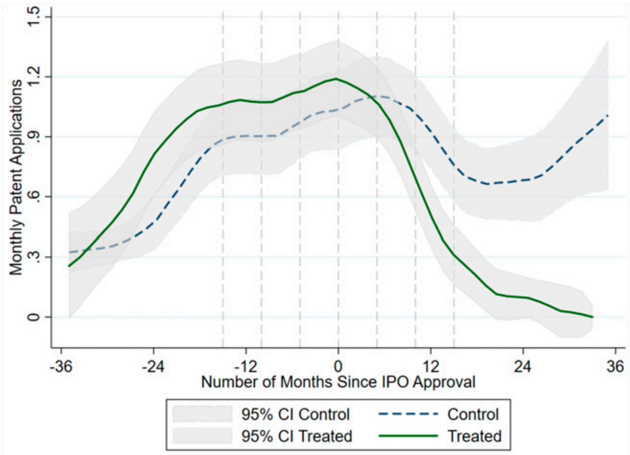
4. Results

This section first describes the effects of suspension-induced IPO delay on patent activity, starting immediately following the suspension when delayed firms are private (Section 4.1.1). We then consider the longer-term effect multiple years after listing approval and after the treated firms publicly list (Section 4.1.2), before showing a number of robustness tests (Section 4.1.3). Other firm outcomes are analyzed in Section 4.2.

4.1. Patent Activity

4.1.1. Immediate Effect of Suspension-Induced Delay on Innovation. Suspension-induced listing delay significantly reduces firm patenting activity. We first show the raw effect visually. Figure 4 contains a local polynomial of the average patents by month around the IPO approval date among treated and control firms. The treated firm data include only firm-months in which the firm has not yet listed. Therefore, all firms are included in the months up until zero (the

Figure 4. (Color online) Average Monthly Invention Patent Applications Around IPO Approval



Notes. This figure shows Chinese invention patent applications by the month around the committee approval date. We sort firm-months around the month that a firm was approved to IPO. For the treated firms, firms drop out of the sample as they list; all firms are included at month zero and before. For control firms, they are included before and after listing. Treatment (n = 118) and control (n = 232) samples are defined in Table 1 and Figures 2 and 3. We use a local polynomial with Epanechnikov kernel using Stata's optimal bandwidth; 95% confidence intervals (CI) shown.

month of approval) and then drop out of the sample as they list. The control firm data include all firm-months. The figure reveals that patent applications rise leading up to approval as firms ready themselves for listing. They may be doing more innovation during this period, but the patent applications could also reflect a need to increase disclosure. It is comforting that firms affected by delay have similar preapproval behavior as firms that do not experience abnormal delay. After approval, patents decline much more for delayed firms.

Table 3 shows estimates of Equation (1). We begin in Panel A with outcomes measured in the 12 months following IPO approval. This period is almost entirely post-IPO for the control group and pre-IPO for the treatment group. The advantage of examining this period is that outcomes are observed around the same calendar time. The disadvantage is that it compares public and private firms, though this has been the approach of the literature on the effect of going public on innovation. Table 3, Panel A, column (1) shows in a Poisson model that the suspension treatment reduces patent applications in the year after approval by 28%.[28] Column (4) uses an ordinary least squares (OLS) model to show that the suspension treatment reduces patents by 1.7 (the mean is 5.01 patents). Columns (2) and (5) find similar results without controls. Columns (3) and (6) more closely approximate an regression discontinuity design (RDD), including controls for the approval date and approval date squared, and find very similar results to the main models. A conservative back-of-the-envelope calculation indicates that assuming constant growth rates for the treated and control groups after IPO approval, it would take 7.7 years after the year of IPO approval to close the gap in patent applications between the two groups.[29]

Suspension-induced delay also reduces patent quality. The treatment reduces granted Chinese invention patents in the year following approval by about 20% in both the Poisson and OLS models (Table 3, Panel A, columns (7) and (8)). For granted global utility patents, the Poisson estimation does not converge because there are too few instances of positive patents. The OLS finds that treatment reduces the number of grants by 0.04 relative to the sample mean of 0.04 (column (9)). Turning to citations, columns (10) and (11) show declines of 36% in the Poisson model and 46% in the OLS model (the sample mean for citations is 23.8).

There may be concern that the decision to patent could be related to the suspensions. For example, it may be that firms choose not to patent their innovations during the suspension because somehow information leakage is exacerbated during this period. To rule this out, we examine citations per invention patent conditional on having a patent in columns (12) and (13). The sample declines significantly, because many firms do not patent at all. Comfortingly, we find similar results, though the OLS specification is not significant. Overall, the results in Table 3, Panel A provide consistent and compelling evidence that suspension-induced delay reduces innovation proxied by patenting activities, both in terms of quantity and quality.

Ferreira et al. (2012) predicts and Bernstein (2015) documents that the quality of internal innovation declines after public listing. Similarly, we observe patent applications fall in both the treatment and control groups after IPO. We further verify in Table A.3 in Online Appendix A that our data are consistent with Bernstein (2015) by decomposing with monthly data the decline of patent citations—the measure of innovation quality used in Bernstein (2015)—into listing and suspension-induced delay treatments. Column (1) shows that, on average, citations fall after IPO. Column (2) shows that this decline persists after controlling for delay. It is notable that the post-IPO decline established by Bernstein (2015) exists not just in the United States but also in China, a very different setting. However, our focus is on policy uncertainty, and our contribution is to show that patent activity falls further and persistently among the treated group.

In the absence of an industrial organization-style model that includes competition between firms, we

Table 3. Effect of Suspension-Induced IPO Delay on Patent Activity

Panel A: Patents filed in year after IPO approval

Dependent variable: Chinese invention patent applications

Model:	Poisson			OLS		
	(1)	(2)	(3)	(4)	(5)	(6)
Treated	−0.33***	−0.30***	−0.35***	−1.7***	−1.4***	−1.8***
	(0.11)	(0.11)	(0.12)	(0.59)	(0.54)	(0.59)
Approval date			0.0042			0.031
			(0.018)			(0.078)
Approval date^2			0.00			0.00
			(0.00)			(0.00)
Controls†	Y	N	Y	Y	N	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	N	Y	Y	N
N	350	350	350	350	350	350
[Pseudo]-R^2	0.14	0.10	0.14	0.14	0.085	0.14

Dependent variable:	Granted Chinese invention patent applications		Granted global (non-Chinese) utility patents	Citations to granted Chinese invention patents		Citations per Chinese invention patent	
Model:	Poisson (7)	OLS (8)	OLS (9)	Poisson (10)	OLS (11)	Poisson (12)	OLS (13)
Treated	−0.22**	−0.36*	−0.041*	−0.45***	−11**	−0.11*	−1.5
	(0.11)	(0.20)	(0.023)	(0.17)	(5.1)	(0.069)	(0.92)
Controls†	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y	Y
N	350	350	350	350	350	200	200
[Pseudo]-R^2	0.10	0.13	0.072	0.20	0.11	0.04	0.09

Panel B: Patents filed in third and fourth years after IPO approval if firm has listed

Dependent variable:	Chinese invention patent applications in third year after IPO approval		Chinese invention patent applications in fourth year after IPO approval	
Model:	Poisson (1)	OLS (2)	Poisson (3)	OLS (4)
Treated	−0.26*	−1.2**	−0.18*	−0.91*
	(0.14)	(0.56)	(0.095)	(0.5)
Controls†	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	342	342	320	320
[Pseudo]-R^2	0.11	0.12	0.12	0.11

Panel C: Patents filed in year after and second year after IPO

Dependent variable:	Chinese invention patent applications in year after IPO		Chinese invention patent applications in second year after IPO	
Model:	Poisson (1)	OLS (2)	Poisson (3)	OLS (4)
Treated	−0.34***	−1.5**	−0.34	−1.4
	(0.13)	(0.57)	(0.24)	(1.4)
Controls†	Y	Y	Y	Y

Table 3. (Continued)

Panel C: Patents filed in year after and second year after IPO				
Industry fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	350	350	350	350
(Pseudo)-R^2	0.13	0.13	0.29	0.43

Notes. Panel A shows the effects of IPO delay on patenting in the year after IPO approval, within the estimation sample of firms approved in the 12 months before an IPO suspension. In columns (3) and (6), we also control for approval date in a more direct RDD approach. Panel B shows the effects of IPO delay on patent applications in the third and fourth year after approval conditional on the firm having already listed (that is, comparison is within public firms). Before this restriction, the sample is the estimation sample of firms approved in the 12 months before an IPO suspension. Panel C shows the effect of IPO delay on patent applications in the year after IPO and second year after IPO, but aligning control firms on the calendar year of the treated firms, so that patents are compared within the same calendar year. This means that control firms are on average further past their IPO than treated firms. We naively instrument for delay with a treated indicator that is defined by an observed discontinuity in delay. For the 2008–2009 (2012–2014) suspension, it is 1 for firms approved on or after June 5, 2008 (April 24, 2012) and before the respective suspension start on September 19, 2008 (October 19, 2012). The R^2 is pseudo for Poisson models. Errors clustered by industry-quarter.

†Controls are revenue, leverage, total investment that year, age, and indicators for being state owned, PE/VC backed, and the exchange (SH/SZ).

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

cannot assess whether the innovation declines we observe in a subset of firms represents an economy-wide reduction. In an unreported test, we find no measurable effects of suspension-induced delay on competitor firms' innovation. The IPO suspensions affected a significant number of companies at a crucial stage in their life cycles, and a decline in their innovation activity may reduce positive spillovers to other firms' innovation and, in turn, affect aggregate growth (Jones and Williams 1998, Bloom et al. 2013). Therefore, our results represent an unintended consequence of IPO market intervention that has at least weakly negative effects on overall innovation in China.

4.1.2. Longer-term Effect of Suspension-Induced Delay on Innovation. We next examine the longer-term effect of suspension-induced delays. Specifically, we consider the third and fourth years following approval, conditional on the firm already having listed. We do not use the second year because many treated firms have not yet listed at this point. The advantages here are that firms are studied at a similar calendar time and are at a similar stage in their life cycle, in the sense of being after the watershed IPO event. We find that the negative effects on patenting, especially applications that proxy for innovation effort, endure for several years and after the treated firms list. Table 3, Panel B shows that in the third year following approval, conditional on having listed, the treated firms average 23% fewer patent applications in the Poisson model, and 1.2 fewer patent applications in the OLS model. The reductions in the fourth year are 16% and 0.91 applications, respectively.

In an alternative specification, we examine effects in the first and second year after IPO. We align control firms to be in the same calendar year as the treatment firms. That is, we shift the time period considered (year t) forward for control firms to make up for the suspension period. For example, many of the control firms for the 2008–2009 suspension listed in 2007. The treated firms mostly listed in 2009. We consider the patents for the control firms in the second or third year after their IPO, so that all firms are considered in (roughly) 2009. Again, this approach compares public firms at a similar stage in the firm life cycle and—importantly—at the same calendar time, so the effects should not be confounded by market conditions. Effects in the year and second year after IPO are shown in Table 3, Panel C. Treated firms have on average 29% fewer patents than the control group in the Poisson model and about 1.5 fewer patents in the OLS model, though these effects lose significance in the second year after IPO.[30]

4.1.3. Robustness Tests. We conduct a range of robustness tests. First, we examine whether the effect is only on the extensive margin of delay by estimating the effect of continuous delay, rather than the naive "treat" instrument. In Equation (2), the coefficient of interest is β on months of delay. The other variables are the same as in Equation (1).

$$P_{jt} = \alpha + \beta MonthsDelay_j + \delta' V_{jt} + \gamma Industry_j + Year_t + \varepsilon_{jt} \qquad (2)$$

Table 4, Panel A, columns (1) and (2) show this effect of continuous delay in months. Each additional month of listing delay is associated with a 1.3% reduction in patent applications in the Poisson model and 0.067 fewer patent applications in the OLS model. To address any concern that firms jump the queue after being approved within this continuous-delay specification, we instrument for the months of delay using the month of IPO approval. The intuition is

Table 4. Robustness in Effect of Suspension-Induced IPO Delay on Patenting

Panel A: Continuous delay and patent applications in year after IPO approval

Dependent variable: Chinese invention patent applications

				Placebo tests		
			Instrument for delay with approval date	Delay exclusive of suspensions		Excluding presuspension periods
Model:	Poisson (1)	OLS (2)	IV (2SLS) (3)	Poisson (4)	OLS (5)	OLS (6)
Delay (months)	–0.013*	–0.067*	–0.12**			–0.071
	(0.0073)	(0.039)	(0.059)			(0.047)
Mock delay (months)				0.012	0.064	
				(0.014)	(0.072)	
Controls†	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y
N	350	350	350	350	350	1199
[Pseudo]-R^2	0.14	0.13	0.13	0.14	0.13	0.11
First stage F-test±			266			

Panel B: Placebo tests using preapproval years

Dependent variable:	Chinese invention patent applications in year before IPO approval		Chinese invention patent applications in second year before IPO approval	
Model:	Poisson (1)	OLS (2)	Poisson (3)	OLS (4)
Treated	0.032	0.051	–0.037	–0.32
	(0.15)	(0.74)	(0.2)	(1.1)
Controls†	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	350	350	350	350
[Pseudo]-R^2	0.28	0.53	0.24	0.42

Panel C: Main results in panel setting with firm fixed effects

Dependent variable: Chinese invention patent applications

	After IPO approval		After IPO	
Model:	Poisson (1)	OLS (2)	Poisson (3)	OLS (4)
Treated·Post	–0.4***	–2.1**	–0.4***	–1.6
	(0.038)	(1)	(0.04)	(1.5)
Post	0.81***	3.4***	1.3***	4.9***
	(0.021)	(0.96)	(0.024)	(1.3)
Firm fixed effects	Y	Y	Y	Y
N	3,234	3,850	2,910	3,500
R^2	—	0.007	—	0.03

Notes. Panel A shows the effects of IPO delay on patenting in the year after IPO approval, within the estimation sample of firms approved in the 12 months before an IPO suspension. Columns (1) and (2) show the effect of continuous delay in months. In column (3), we instrument for continuous delay with the approval date. Columns (4) and (5) are placebo tests that use "mock" delay that excludes months during the IPO suspensions. Column (6) is a placebo test that uses delay outside of the estimation sample, during periods other than the 12 months before an IPO suspension. Panel B shows placebo tests of the effect of IPO delay on patent applications in the years before IPO approval. We naively instrument for delay with a treated indicator that is defined by an observed discontinuity in delay. For the 2008–2009 (2012–2014) suspension, it is 1 for firms approved on or after June 5, 2008 (April 24, 2012) and before the respective suspension start on September 19, 2008 (October 19, 2012). Panel C shows the effect of suspension-induced IPO delay on invention patent applications using a panel setting with firm fixed effects. Columns (1) and (2) consider the five years around IPO approval. Columns (3) and (4) consider the five years around IPO. Treated is defined at the firm level as in previous tables, but the coefficient of interest is now the interaction between being treated and in the post period (after approval in columns (1) and (2), and IPO in columns (3) and (4)). The R^2 is pseudo for Poisson models, but in Panel C with panel data there is no pseudo R^2 reported. Errors clustered by industry-quarter in Panels A and B and by firm in Panel C.

†Controls are revenue, leverage, total investment that year, age, and indicators for being state owned, PE/VC backed, and the exchange (SH/SZ).

±The Cragg-Donald F-statistic for the excluded instrument (delay) being significantly different from zero.

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

that if firms do not jump the queue to list after being approved, the month of approval should predict the duration of delay. The first stage consists of Equation (3), where ApprovalMonth$_t$ is a fixed effect for the month of approval.

$$\widehat{MonthsDelay}_j = \alpha + \text{ApprovalMonth}_t + \delta' \text{V}_{jt} + \gamma Industry_j + Year_t + \varepsilon_{jt} \quad (3)$$

As expected from the absence of queue-jumping, the first stage is very strong, with an F-statistic of 260, well above the rule-of-thumb cutoff of 10. (We do not report the first stage as there is a very large number of coefficients.) Instrumented delay has a significant effect on innovation, shown in Table 4, Panel A, column (3). The coefficient is larger in the IV model, at −0.12 relative to, for example, −0.067 in the OLS model.

These two coefficients are not statistically significantly different from one another, but it is worth considering why the IV effect is larger. First, compliers with the IV have a larger effect than average because their delay is much longer and includes uncertainty. The IV permits a more discontinuous effect of delay (closer to the discrete effect of $Treat_j$ in the main models), whereas the OLS measures the average effect of delay, which includes firms that experience only normal processing time. If the main effect reflects the uncertainty mechanism, then the OLS confounds estimation by using all months of delay. Also, there could be upward bias in the OLS, for example, if firms do more patenting when they have a bit more normal processing delay or they try to rush through patent applications before listing in order to have a better market response. The IV isolates suspension-induced delay and thus eliminates such potential upward bias.

We also conduct several placebo tests. First, we construct "mock" delay that excludes the months during the IPO suspensions. For example, if a firm has 13 months of delay, of which 9 occurred during a suspension, its mock delay would be 4 months. The goal is to test whether innovation is affected by minor differences in delay from variation in normal delay (that is, processing time in nonsuspension periods). The results are in Table 4, Panel A columns (4) and (5). The null effects demonstrate that suspension-induced delay affects innovation, whereas variation in normal processing time does not. Second, we use delays (in months) in the nonestimation sample (i.e., outside the 12 months before an IPO suspension). Table 4, Panel A, column (6) contains this placebo test of delay outside of the estimation sample and yields no effect. This obviates an argument that high-quality firms tend to list faster and experience less delay, because then the mock delay in columns (4)–(6) should also be associated with less innovation. A third placebo test examines the years before IPO approval for the treated and control groups, which is similar to testing for differences in pretreatment characteristics. If nonsuspension-related factors are the primary drivers for our findings, we expect similar findings in these placebo tests as in our main specifications. Table 4, Panel B shows the effect of IPO delay on patent applications in the years before IPO approval and finds no effect.

To further establish the robustness of the effect, we use a panel setting with firm fixed effects. This compares the change in innovation output between treated firms and control firms before and after the IPO suspensions. We conduct this test for the 5 years before and after the approval year and the IPO year, so that a maximum of 11 years is included for each firm. The coefficient of interest is the interaction between being treated and in the postperiod. The results in Table 4, Panel C, columns (1) and (2) show that the results are robust to the panel setting. For example, the Poisson coefficient is −0.4, significant at the 0.01 level, somewhat larger than the −0.33 found in the primary approach. Columns (3) and (4) consider the five years around IPO. They also show large negative effects, though the OLS result is not statistically significant. The sample size differs across the models in this panel for two reasons. First, Poisson drops groups with no patents. Second, truncation reduces the sample size around IPO, which occurs after approval.

Finally, we conduct a number of unreported robustness exercises, including adding a battery of additional controls to ensure the results do not reflect changes to firm fundamentals rather than delay. Controlling for variables related to governance, such as the number of board members, and for measures of size and financial status, such as payroll, assets, and total debt, does not affect the results. Taken together, the robustness tests confirm that IPO suspensions are the main driver for the observed differences in patent activities by delay treatment status.

4.2. Other Firm Outcomes

We consider the effect of suspension-induced delay on firm outcomes besides innovation in Table 5. In the year after IPO approval, we find a positive effect on leverage, negative effects on tangible investment and return on sales, and no measurable effects on sales or earnings (Panel A). The effects on leverage and tangible investment are consistent with the firm experiencing a negative capital shock and heightened business uncertainty as a result of suspension-induced delay, which helps explain why they may have less capacity for investing in innovation or commercializing existing inventions (both of which may be reflected in reduced patent applications). Table 5, Panel B shows that these effects quickly dissipate after the IPO. This panel includes additional outcomes, as we observe more corporate variables after IPO than

Table 5. Effect of Suspension-Induced IPO Delay on Corporate Outcomes

Panel A: Effect in year after IPO approval

Dependent variable:	PPE investment (1)	Leverage (2)	Revenue (3)	Return on sales (4)	Earnings (5)	Discretionary accruals (6)
Treated	−0.038***	0.23*	−287	−0.56***	−14	−0.014
	(0.013)	(0.12)	(2,726)	(0.094)	(240)	(0.015)
Controls	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y
N	350	350	350	350	350	340
R^2	0.14	0.38	0.18	0.5	0.91	0.12

Panel B: Effect in year after IPO

Dependent variable:	PPE investment (1)	R&D/assets (2)	Log R&D (3)	Leverage (4)	Revenue (5)	Board size (6)
Treated	−0.011	−0.0019	−1.1	−0.13	211	0.55
	(0.018)	(0.0012)	(1.9)	(0.22)	(5,740)	(0.37)
Controls	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y
N	350	339	339	350	347	350
R^2	0.16	0.14	0.18	0.45	0.21	0.27

Dependent variable:	Market share (7)	Return on sales (8)	Earnings (9)	Cash/assets (10)	Discretionary accruals (11)
Treated	0.0022	0.016	−65	0.029	0.016
	(0.003)	(0.016)	(721)	(0.031)	(0.021)
Controls	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y
N	345	350	350	335	339
R^2	0.34	0.33	0.24	0.34	0.16

Notes. Panel A shows the effect of IPO delay on other outcomes in the year after delayed firms IPO, within the estimation sample of firms approved in the 12 months before an IPO suspension. We naively instrument for delay with a treated indicator that is defined by an observed discontinuity in delay. For the 2008–2009 (2012–2014) suspension, it is one for firms approved on or after June 5, 2008 (April 24, 2012) and before the respective suspension start on September 19, 2008 (October 19, 2012). The R^2 is pseudo for Poisson models. Errors clustered by industry-quarter.

†Controls are revenue, leverage, total investment that year, age, and indicators for being state-owned, PE/VC-backed, and the exchange (SH/SZ).

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

before. Although most effects are insignificant, the effect on R&D scaled by firm assets is nearly significant at the 10% level, suggesting that delayed firms may invest less in R&D immediately after listing. For all these variables, we continue to find null effects when we consider multiple years after IPO approval conditional on listing.

5. Mechanism Discussion

This section considers mechanisms that may explain the results, with a focus on policy uncertainty as the channel best supported by the evidence.

5.1. Policy Uncertainty

The suspensions, which were all of indefinite length, created uncertainty among affected firms about when they would be able to go public and what market conditions they would face. Intuitive heterogeneity tests support this channel, where we interact treatment with a cross-sectional variable. We expect that firms with greater dependence on risky innovation will experience larger effects. We use two proxies for this dependence, R&D intensity and an indicator for the firm having received private equity or venture capital before applying to list (VC/PE backing). The relationship to VC/PE backing is not obvious. On one hand, Tian and Ye (2018) find that PE/VC-backed firms suffer more from holdup problems and as a result VCs respond to policy uncertainty with more staging and reduced investment. PE/VC-backed firms are also likely riskier and more innovative (or have greater innovative capacity/potential). For these reasons, we expect under the uncertainty channel that they will be more affected. On the other hand, these firms can presumably return to their private backers for capital, so we expect under the financing constraints mechanism that they would experience a smaller effect. We find that both high R&D intensity and VC/PE-backed firms are much more affected than their less-risky counterparts (Table 6, columns (1) and (2)), providing support for the uncertainty channel.[31] Note also that many mechanisms, including financial constraints, should affect normal processing time delay. Yet the placebo tests reported in Table 4, Panels A and B show that such normal delay does not affect innovation.

To push further on whether there was meaningful uncertainty about the IPO market during suspensions, we examine VC investment. If IPO suspensions were perceived as short and unimportant hiatuses, contemporaneous VC investment should not be affected because VC investments are relatively illiquid. Conversely, if suspensions caused serious uncertainty about the future of IPO markets in China, VC investors may have become concerned about exit possibilities and reduced investment. We show an association between VC investment and the suspensions in Online Appendix B. Controlling for domestic market conditions and rest-of-world VC, we find that the suspensions were associated with depressed VC investment, particularly later-stage VC investment, in Chinese portfolio companies. This phenomenon persists among elite U.S.-headquartered VC firms active in China. Although not causal, this analysis suggests that the suspensions had a chilling effect on VC. Note that market expectations may play a role here as well; however, we find a similar

Table 6. Heterogeneity in Effect of Suspension-Induced IPO Delay on Patenting

Dependent variable: Chinese invention patent applications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treated·High R&D intensity	−0.84*							
	(0.49)							
Treated·PE/VC Backed		−0.45**						
		(0.21)						
Treated·State Owned			0.32					
			(0.33)					
Treated·High Market Share				0.22				
				(0.21)				
Treated·High Tech Non-SOE					−0.32			
					(0.23)			
Treated·Age						0.022		
						(0.033)		
Treated·Sales							−0.000024	
							(0.000017)	
Treated·Assets								1.4e-07
								(3.3e-06)
Treated	−0.074	−0.068	−0.34***	−0.3*	−0.067	−0.57	−0.64***	−0.31***
	(0.15)	(0.18)	(0.11)	(0.16)	(0.22)	(0.39)	(0.2)	(0.12)
Control for independent effect	Y	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
N	320	350	350	320	350	350	350	350
Pseudo-R^2	0.12	0.15	0.07	0.15	0.14	0.14	0.15	0.15

Notes. This table shows the effect of IPO delay on patenting in the year after IPO approval, within the estimation sample of firms approved in the 12 months before an IPO suspension. We report only the interaction coefficient and not the independent effect of the characteristic of interest (e.g., High R&D intensity) for brevity. Treatment is interacted with the following variables for the firm having certain characteristics in the IPO year: High R&D intensity = 1 if R&D/assets above median; State Owned = 1 if State Owned Enterprise (SOE); High market share = 1 if market share above median; High Tech Non-SOE = 1 if in a high-tech industry and not SOE; PE/VC-backed = 1 if received private equity before applying to list; Age = firm's age in years; Sales = Total sales in millions of RMB; Assets = firm assets in millions of RMB. In columns (1) and (3), we use the outcome from Table 3, Panel B, columns (1) and (2) because the covariate in the interaction is only observed after IPO. We naively instrument for delay with a treated indicator that is defined by an observed discontinuity in delay. For the 2008–2009 (2012–2014) suspension, it is 1 for firms approved on or after June 5, 2008 (April 24, 2012) and before the respective suspension start on September 19, 2008 (October 19, 2012). All models are Poisson. Errors clustered by industry-quarter.

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

pattern using only suspensions in which the market is not in a downturn at the time the suspension is announced. Together, our micro- and macroevidence on IPO delays and VC contributes to literature on the relationship among VC, innovation, and going public (Brav and Gompers 1997, Krishnan et al. 2011, Cao et al. 2015).

These findings are consistent with the large body of literature on real options and investments under uncertainty. The real-options models establish that increased uncertainty depresses current investment because the interaction of capital irreversibility and uncertainty generates positive option value to deferring investment (McDonald and Siegel 1986). Investment in innovation is highlighted in this literature as a particularly relevant example because it is often project specific with high labor costs, making funds difficult to recoup if the project fails (e.g., Grabowski 1968, Dixit and Pindyck 1994). Indeed, we find strong negative effects of suspension-induced delay on tangible investment in the year following IPO approval, shown in Table 5, Panel A. Tangible investment is longer-term and risky relative to other types of expenditure. In sum, we find substantial support for uncertainty as a primary channel for our main effects.

5.2. Long-term Impact, Cumulative Innovation, and Managerial Changes

A remaining question is why temporary uncertainty would have lasting effects on innovation, unlike, for example, tangible investment or return on sales. The most natural explanation is that innovation investments are cumulative, such that investing today sets the stage for continuing to have positive net present value (NPV) investment opportunities in the future. That is, the productivity of firms' future innovation investment depends on whether it remains at the frontier today and maintains its R&D infrastructure. As Holmstrom (1989, p. 7) points out, "innovation is risky, unpredictable, long-term and multi-stage." This explanation relates to the literature showing how innovation capability depends on years of accumulated expertise and infrastructure (e.g., Feldman and Florida 1994, Bates and Flynn 1995). New innovations build upon and complement prior innovation (Chang 1995). Manso (2011) formalizes corporate innovation as a cumulative, multistage process. He shows that incentive schemes that motivate innovation require substantial tolerance or even reward for early failures while compensating long-term success. Commitment to long-term plans, job security, and timely feedback is an essential ingredient to motivate innovation. All these entail investments that are not easily adjustable and outcomes that are dependent on long-term, cumulative efforts. Both Manso (2011) and Manso (2017) argue that regulations limiting the ability of firms to invest in long-term, exploratory innovation may have negative consequences.

The notion of cumulative innovation is analogous to an individual's investment in education to build human capital, as Cunha and Heckman (2007) formalize. Attending third grade offers little in the way of labor market returns but is crucial to ultimately attending college. A child who misses a year of schooling may fall permanently behind his or her peers. Similarly, falling behind in the corporate innovation process may have persistent effects. Uncertain listing delay causes a firm to pause its innovation investment, disrupting its ability to build or maintain an innovative, entrepreneurial culture in the sense of Gompers et al. (2005). The temporary disruption has effects on the firm's innovation infrastructure that last for multiple years. More broadly, short-term treatments are known to have enduring effects on people (e.g., Drago et al. 2009). In sum, in light of the long-term, risky nature of innovation relative to other investment types, it is natural that even short-term uncertainty may have enduring effects.

Another remaining question is how uncertainty would affect corporate decision making in the operational sense. Manager tolerance for failure and interest in experimentation is one channel for how uncertainty might affect innovation in the long run. Manso (2011), Tian and Wang (2014), Kerr et al. (2014), and Manso (2017) argue that experimentation and tolerance for initial failure are important for successful innovation. Experience with delay could affect manager approaches to innovation, similarly to how negative experiences with the Great Depression have been shown to affect managerial risk appetite (Malmendier and Nagel 2011). In this case, we expect that managers whose tenures span the delay period and the post-IPO period will be responsible for the negative effects on post-IPO innovation. Note that simply observing the uncertain IPO environment should depress innovation at the control firms; instead, this mechanism requires managers to themselves experience suspension-induced delay. This is one way beyond those posited above that initial negative innovation effects could become cumulative. That is, changes in managerial preferences may depress innovation even after policy uncertainties have resolved.

To investigate this mechanism, we collect data on executive changes using the CSMAR Executive and Board Database.[32] In Table A4 in Online Appendix A, we interact treatment with an indicator for whether the firm's chief executive officer (CEO) changed between approval and IPO. The interaction coefficient is robustly positive, implying that firms that changed CEOs do more innovation after suspension-induced delay than continuing CEOs. Of course, changing the CEO is endogenous and could emerge from the board's desire to "clear the slate" after delay. In Table A5 in Online Appendix A, we document that suspension-induced delay does not lead to changes in management, suggesting no systematic attempt to clear the slate.[33] Although these tests are only suggestive, they provide support for a decline in experimentation or tolerance for failure as a plausible channel for how uncertainty can affect innovation in the long run.[34]

5.3. Financial Constraints

Beyond policy uncertainty, access to finance is also relevant for productivity and innovation (e.g., Butler and Cornaggia 2011, Mao and Wang 2018, Howell 2020). In our setting, financing constraints during the suspensions interact with heightened uncertainty, leading to lower corporate innovation.[35] For financial constraints to play a key role in explaining our findings, alternative forms of financing must be too costly or unavailable. As explained in Section 2.2, firms must meet various financial requirements, including multiple years of profitability, in order to list. This implies that firms approved to IPO in China are unlikely to be extremely financially constrained. Also, the effort to obtain IPO approval is sunk, so firms desperately in need of capital might be expected to seek an IPO in Hong Kong or elsewhere. The fact that listing abroad does not occur in our sample implies that the firms are not financially constrained, that firm-specific factors make them less well suited to listing abroad, or that they face severe frictions to listing abroad.[36]

In the absence of financial frictions, the delayed firm could also fill a financing gap with debt or VC/PE. Frictions in these markets may make IPO markets especially important for risk capital provision in China. This is consistent with our findings that during the suspension-induced delay period, affected firms experience higher leverage, whereas patenting and tangible investment falls (Tables 3 and5). In the year following IPO, suspension-induced delay is not associated with lower investment but continues to lead to higher leverage. It seems that firms are able to increase debt but that the debt is not used to finance risky investments—tangible assets and innovation. Firms appear to be in a "Goldilocks" position given that these activities may be constrained by the absence of risk capital (Atanassov et al. 2007). They are not so constrained that they cannot raise any debt, but frictions prevent them from financing risky projects effectively in the absence of public capital.

In a financial constraint channel, we expect firms with PE/VC investment or better access to debt to be less affected because they could presumably turn to these other financing sources during the delay period. We would also expect to observe larger effects for firms that are more financially constrained. To assess this, we conduct a number of heterogeneity tests in Table 6. First, we expect that firms with prior PE/VC backing may be able to return to this source more easily for bridge financing during the delay and that SOEs have better access to debt in the years we examine (e.g., Cong et al. 2020a). Yet PE/VC-backed firms are more rather than less affected (column (2)) and SOEs are not significantly less affected (column (3)).[37] We also do not find that treated firms are more or less likely to ever receive PE/VC investment before their IPO, suggesting that firms do not react to suspension-induced delay by raising money in private capital markets. We next consider standard measures of financial constraints: age and size (Chirinko and Schaller 1995, Whited 2006, Duchin et al. 2010). These are appropriate in China, where more complex measures based on, for example, detailed industry, dividends, or debt financing costs are either unavailable or may not have the same informational content. In columns (6)–(8), we find near-zero and insignificant effects on interactions between treatment and firm age, sales, and assets in the year of IPO.

In sum, although a capital supply channel is likely part of the story, it does not fully explain the chilling effect of suspension-induced delay on innovation. This is consistent with other studies about firms in China finding a limited role for financial constraints, including Li and Yang (2013), He et al. (2020), and Tan and Zhang (2017). Of course, our findings by no means imply that constraints are unimportant in other settings. Finally, note that to the degree financial constraints are at play in reducing innovation during the delay period, the cumulative nature of innovation and altered manager preferences could generate persistence, as explained in the previous section. Yet because we do not find that more financially constrained firms experience more negative long-term effects, the evidence favors an uncertainty channel as the primary mechanism for the long-term effect of IPO delay on innovation.

5.4. Window Dressing and Other Alternatives

Our robustness tests already rule out several alternative channels for the effects of suspension-induced delay on innovation. A remaining one is window dressing behavior, or efforts to artificially and temporarily mislead the market about the firm's worth (Stein 1989, Jain and Kini 1994). Window dressing is almost certainly present and may help explain the run-up in patent applications that we observe two years prior to the firm's approval (Figure 4). We examine the standard measure of window dressing, discretionary accruals, in the year after IPO approval. If anything, we find that treated firms have slightly lower, albeit statistically insignificant, discretionary accruals (Table 5, Panel A, column (6) and Panel B, column (11)). It is therefore unlikely that window dressing alone explains the innovation decline among the treatment group.

However, firms could have exhausted window dressing resources during delays and thus have less flexibility to window dress after IPO. That is, firms may maintain short-term operating performance at the expense of longer-term operating performance, which could have reduced patent activities. Yet this version of window dressing cannot explain the persistent effects on innovation that we observe during suspension-induced delay and several years after, jointly with the absence of a longer-term effect on operating performance. Similarly, firms may perceive a need to maintain a certain standard of innovation under the CSRC's watch as they wait to list. In particular, if a firm exhausts resources for innovation during delay, we might expect it to have lower innovation after ultimately going public. However, we observe patent applications drop precipitously during the suspension-induced delay period (Figure 4), which directly contradicts this hypothesis. A final possible window dressing scenario is that treated firms temporarily inflate patent activities prior to the approval meetings more than control firms do and subsequently have less resources for patent activities afterward. Yet Figure 4 shows that this is not the case; instead, control and treated firms exhibit similar patterns in patenting prior to approval.

6. Conclusion

This paper sheds light on how financial policy uncertainty affects innovation. The ideal experiment would observe the same economy with and without well-functioning public markets and observe policy uncertainty shocks that do not overlap. To this end, China's IPO suspensions provide a useful quasi-experiment in an important economy. During a suspension, treated firms are forbidden from listing and face an uncertain period of delay. This setting allows us to isolate the immediate and long-term effects of indefinite but temporary exclusion from public markets. We find that IPO suspension-induced delay reduces innovation with economically significant magnitudes. This effect endures for years after listing, whereas effects on other corporate outcomes do not outlast the delay period.

The evidence is most consistent with heightened uncertainty disrupting the corporate innovation process. Our findings not only add to the literature on the real consequences of policy uncertainty but also have regulatory implications, particularly in light of how crucial private firm innovation is to China's future growth. From the perspective of firms seeking public financing, our results suggest that predictably listing in a timely manner is valuable. Therefore, China's innovation ecosystem could potentially benefit if regulators focused on fostering accessible IPO markets with transparent rules and minimal ad hoc intervention. One approach could be to move toward a registration-based, disclosure-oriented listing process with lower policy uncertainty.

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Endnotes

[1] This may reflect the sunk cost fallacy, as the firm will have expended considerable resources to apply to IPO in China. It could also reflect the expectation of a more favorable domestic market valuation or firm-specific factors that make the firm poorly suited to IPO on a foreign exchange.

[2] Previous work on Chinese firm innovation has relied primarily on patent counts. To our knowledge, we are the first to gather comprehensive data on citations for Chinese patents from global patent offices and to include citations to SIPO patents beyond WIPO family patents. We present findings using both SIPO data and global patent data, but Wei et al. (2017) indicate that patent quality is not lower in China than elsewhere.

[3] The dynamics that we observe among treated firms—depressed innovation activity during the delay period and after IPO—indicate that window dressing, a well-known practice during the IPO process, cannot be the main mechanism at play, because it does not predict a medium-term impact after IPO. We also find that firms with suspension-induced delay have slightly lower discretionary accruals, a standard measure of window dressing.

[4] For discussions on IPO interventions, see https://www.globallegalinsights.com/practice-areas/initial-public-offerings-laws-and-regulations (general description), https://www.globallegalinsights.com/practice-areas/initial-public-offerings-laws-and-regulations/india#chaptercontent3 (India), https://www.globallegalinsights.com/practice-areas/initial-public-offerings-laws-and-regulations/mexico (Mexico), and Prasad et al. (2006) on Malaysia.

5 There is no convincing evidence that suspensions stabilized the market, one of the supposed objectives (Packer et al. 2016 and Shi et al. 2018). Although some policies explicitly aim to encourage innovation (e.g., Lerner 2009, Howell 2017), many others may have unintended consequences for innovation.

6 Innovation is prominently listed as the first guiding principle of economic policy in the 13th Five-Year Plan for 2016–2020. See http://www.xinhuanet.com//politics/2016lh/2016-03/17/c_1118366322.htm.

7 See http://opinion.caixin.com/2017-06-09/101099928.html.

8 See Cao et al. (2016) and http://finance.sina.com.cn/stock/y/20150704/195622592273.shtml. The official document outlining the IPO process is available in Chinese at http://opinion.caixin.com/2017-06-09/101099928.html.

9 The CSRC discloses the queue for application: http://www.csrc.gov.cn/pub/newsite/zjhxwfb/xwdd/201511/t20151106_286122.html.

10 Regulating IPOs is one of the major ways that the Chinese government has historically sought to protect investors. All applicants must meet the following requirements: (1) Positive net profits for the last three fiscal years prior to the application, and the cumulative net profit in the three years must exceed RMB 30 million; (2) cumulative revenue in the three years prior to the IPO must equal at least RMB 300 million or cumulative cash flow from operation in three years prior to the IPO must be at least RMB 50 million; (3) intangible assets cannot account for more than 20% of total assets; (4) net assets in the year before the IPO must total at least RMB 30 million; (5) the company did not suffer any unrecovered losses at the end of its most recent fiscal period. In addition to these financial performance requirements, firms are subject to other nonfinancial requirements, such as the existence of a functioning corporate governance system and no record of illegal behavior or financial scandals.

11 See, for example, http://finance.sina.com.cn/stock/stocktalk/20131011/084016956195.shtml.

12 See Yang 2013b and Liu et al. 2013. See also http://www.xinhuanet.com/fortune/2019-01/02/c_1123934625.htm, http://www.csrc.gov.cn/pub/zjhpublic/ and http://www.csrc.gov.cn/pub/zjhpublic/G00306203/201806/t20180601_339051.htm. In addition to considering applicants' quality, the CSRC also controls the aggregate approval rate based on market conditions (Guo and Zhang 2012).

13 Note that the most recent five suspensions did not affect seasoned equity offerings at all (based on detailed data from http://stock.hexun.com/zfsj).

14 See, http://finance.sina.com.cn/stock/stocktalk/20131011/084016956195.shtml, http://www.csrc.gov.cn/pub/newsite/zjhxwfb/xwdd/201511/t20151106_286122.html, http://finance.ce.cn/rolling//201310/01/t20131001_1574723.shtml, and https://workingcapitalreview.com/2015/12/chinas-long-ipo-process-hinders-more-than-just-stock-offerings/.

15 Based on interviews with Liliang Zhu, deputy director of CSRC's Department of Public Offering Supervision, Feng Yu, deputy director of CSRC Zhejiang, and George Jiang, a partner at Springs Capital. The latter noted that although many funds tend to speculate on the timing and duration of IPO suspension, few get it right. See also articles and CSRC documents, such as at http://finance.sina.com.cn/stock/stocktalk/20131011/084016956195.shtml and http://www.csrc.gov.cn/pub/newsite/zjhxwfb/xwdd/201511/t20151106_286122.html, http://finance.ce.cn/rolling//201310/01/t20131001_1574723.shtml, https://workingcapitalreview.com/2015/12/chinas-long-ipo-process-hinders-more-than-just-stock-offerings/, http://finance.sina.com.cn/stock/y/20150704/195622592273.shtml, and http://opinion.caixin.com/2017-06-09/101099928.html. Also quoting fund managers at Longteng Asset management and StaRock Investment, "SEC announced that IPO is about to restart. We can tell that the market has recovered from the surge in brokerage stocks and the turnover of more than one trillion. We thought it was not until 4000 points that the issuance of new shares were resumed. The restart is ahead of schedule unexpectedly."

16 Suspension announcements often cite abnormal falls of the indices, 327 debt event that disrupted normal trading as the reasons. The latest suspension in 2015 was due to abnormal volatile movments in the stock market. See http://finance.sina.com.cn/stock/y/20150704/195622592273.shtml and http://opinion.caixin.com/2017-06-09/101099928.html. Shi et al. (2018), also provides a discussion.

17 Calculated among control and out-of-estimation-sample firms.

18 A few outliers are excluded for visual clarity. Two firms in our sample have listed after the start date of the first suspension. One firm is Jiangsu Huachang Chemical Co. (SHE: 002274). This firm listed eight days after the suspension. We have confirmed with the firm as well as the CSRC that this firm listed in Shenzhen on September 24, 2008 despite the officially recognized earlier start date of the suspension. The other firm is Shanghai Electric (SHA: 601727), which had a share swap with its subsidiary on the Hong Kong stock exchange, Shangdian Stock, after which the shares of Shangdian Stock were delisted. In fact, the issue of all the shares is used to absorb and merge Shangdian Stock's shares, and the listing is not in the strict sense an IPO. Similarly, Zhejiang Shibao (SHE: 002703) listed in November 2012 during the second suspension we examine when it was already listed in Hong Kong. The scale of fundraising by Zhejiang Shibao was also extremely small, with a public offering of only 15 million shares, well below the 65 million listed in the CSRC's approval (Yang 2013a). The results are robust to excluding these firms.

19 A Kendall's tau test finds that more than 96% of all pairs maintain their original order in the second sequence within a given quarter or year. About 11% of firms list more than a week out of order; but conditional on being out of order, the average is only about two weeks out of order. Omitting these firms does not affect our main results.

20 Regarding this observation, it may be that firms in the estimation sample are of higher quality or it may reflect the estimation sample being later in time than the full sample combined with a secular increase in patenting over time. We confirm that Chinese firms have increased their patenting activity over time, consistent with this latter explanation. Regardless, the difference should not bias our analysis of the cross-section of firms, especially when aligned on calendar time.

21 Various sources cite dates between September 16 and 19, 2008 as the starting date. As Table A.1 in Online Appendix A discusses, the main trigger for the suspension is a record low of 1,802.33 points of A shares on September 18. We therefore take September 19, 2008 as the starting date.

22 The small number of observations around the boundary prevent us from using a conventional RDD.

23 China has three classes of patents: invention, utility model, and design. Utility model patents represent new technical solutions relating to the shape, the structure, or their combination, of a product; and design patents cover new designs in relation to shapes, patterns, colors, or their combination, of a product. Applications for these two types are essentially never rejected.

24 Only 18 firms were approved and dropped out, primarily because regulators found evidence of fraud. No firm approved to IPO in our sample has failed to do so and listed abroad instead.

25 Patent applications in China have increased dramatically since China established formal patent law in 1985, and there are now more invention patents filed in China than in the United States. Fang et al. (2017) show that although average quality may differ across countries, patents generally serve the same purpose in China as they

do in the United States; firm patenting behavior is similar across the two countries. For example, in both countries, within-firm increases in patent stocks are associated with higher productivity, exports, and new product revenue. Interestingly, they find that SOE patents are more associated with total factor productivity (TFP) growth than private firm patents. Wei et al. (2017) find that the patent approval rate is not unusually high in China and present comparisons suggesting robust improvement in Chinese patent quality over time.

[26] China's patent office (SIPO) does not disclose citation data, and prior work has primarily relied on citations to patents that Chinese firms file in foreign countries. This approach has several limitations, including selection into foreign patent filing, different standards across offices, and home country bias (Michel and Bettels 2001, Harhoff et al. 2003, Bacchiocchi and Montobbio 2010). In contrast, Google Patent covers SIPO citations and is searchable for non-English patents, providing wider coverage than previous measures.

[27] We measure discretionary accruals as the residual from a Jones model, adjusted by a performance-matched firm, following Jones (1991) and Brau and Fawcett (2006).

[28] We follow Aghion et al. (2005) in using the Poisson for patent counts, though the results are robust in a negative binomial model. Note that the coefficient of −0.33 is interpreted as $1 - e^{-0.33} = 0.28$.

[29] This is based on statistics from Table 2 Panel C, Table 1 Panel A, and Table 3 Panel B. We calculate the annualized growth rates of the mean number of patent applications for the treated group and the control group, which are −2.11% and 2.15%, respectively. Several alternative approaches result in longer time periods to close the gap.

[30] These approaches either omit the most delayed firms or study outcomes long after IPO for control firms. Hence, it is little surprise that these results are somewhat noisier than other estimates. We find similar results to the ones shown here when we do not align on calendar time. We find longer-term effects on patent quality, but they are generally not statistically significant. In part, this reflects the fact that the citation measures are noisier in the Chinese setting and suffer from truncation (Boeing and Mueller 2016).

[31] We use the Poisson model for brevity, but the results are similar with OLS. We omit controls throughout so that the interaction coefficients are more easily interpretable. The results are similar with the controls used in the other tables.

[32] This is only available after IPO and is not available for about 300 firms out of the overall sample. We manually translate and classify positions that appear more than 50 times in the database. We examine entry and exit of holders of these positions in the years after IPO. On average, 2.3 executives or board members depart in the year after IPO, whereas just 0.09 join. Board members account for most of those who depart; but in all categories (e.g., technology executives, finance executives), the departure rate vastly outpaces the entry rate.

[33] Columns (1) and (2) show no effects on CEO change or the entry of new board members. Columns (3)–(7) consider the number of executives who enter in different functions: finance, operations, technology, and human resources, as well as a broader "All" category that includes these and several others. Summary statistics for these dependent variables are in Table A6 Online Appendix A.

[34] Experiencing transitory financial constraints, however, does not lead to the managers behaving differently toward innovation, because we do not see more constrained managers innovate less after public listing.

[35] We cannot completely rule out that the longer-term effect on the patenting rates is an artifact of patent filings and approvals lagging investment for years. However, the fact that firms immediately experience a drop in patenting activities after the suspension cannot be attributed to this lag. Also, this alternative continues to imply a cost to restricting timely access to public markets and has the associated policy implications.

[36] Although there are compelling arguments for listing abroad (e.g., Gounopoulos and Huang 2017), high communication or postlisting disclosure costs may prevent firms from doing so. Except for the largest ones, most firms also expect higher liquidity and valuation when listing domestically. The exceedingly high valuations in China surely offer a powerful inducement to wait to list once approved. One recent example is the online security firm 360 Security, which in 2016 delisted from the NYSE and listed in Shanghai. Its market capitalization rose from $9.3 billion on the NYSE to $52 billion on the Shanghai exchange (here). Finally, firms already applied to list domestically may abstain from listing abroad because of firms executives' behavioral biases, which we are agnostic of and should not alter our main findings. Listing choice is beyond the scope of this paper, and the reader is directed to Doidge et al. (2009a) and Doidge et al. (2009b) for discussion.

[37] The negative and significant coefficient on Treat*PE/VC Backed in column (2) of Table 6 could suggest that the PE/VC investors are unwilling to provide funds to firms facing policy uncertainty (the supply side), which leads to a lack of funds for innovative investment. Similarly, the insignificant coefficient on Treated*SOE in column (3) of Table 6 could also suggest that SOEs have more agency issues and, hence, are less likely to invest in innovative investment.

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