From Private to Public: Pharmaceutical R&D Following an IPO

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Abstract

An initial public offering (IPO) is an important pathway for innovative firms to obtain key financial and strategic resources. In the biopharmaceutical sector—where smaller, financially constrained firms invest in risky projects and selectively withhold product quality information—going public can enable access to risk capital and act as a signal of quality to potential collaborators and employees. Using detailed drug development, licensing, and publication data, we find that going public increases firms' product development efforts. These effects are greatest among small firms, who significantly increase their co-development activity with other firms and hire more researchers. These findings suggest that, for such firms, the benefits of increased access to key resources through the transition to public markets can offset potential negative effects.

Keywords: Innovation; Research and Development; Project Selection; Initial Public Offerings

1 Introduction

This paper examines the impact of public capital markets on firms' access to key resources for new product development. We focus on the biopharmaceutical industry, where firms seeking to bring new products to market must navigate significant scientific, market, and regulatory uncertainties. Access to key financial and strategic resources, such as capital, collaborators, and skilled personnel, is often viewed as crucial for success. This context provides an ideal setting to investigate how the transition to public markets enables firms to access important key resources and its effect on product development. We compare the product development outcomes of firms that seek and eventually

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complete an initial public offering (IPO) with those of similar firms that intend to go public but ultimately withdraw their filings (Bernstein, 2015). We find that going public boosts late-stage product development, with the effects greatest among smaller firms. These firms significantly increase their co-development activities and hiring efforts, suggesting that going public can significantly reduce financial frictions and information asymmetries.

It is well-established that in capital-intensive industries, public financial markets play an important role in firms' innovative incentives (Brown et al., 2009; Hsu et al., 2014; Kerr and Nanda, 2015; Levine, 1997). Access to public financial markets and key resources may help financially constrained, less experienced firms increase their innovative activity (e.g., Arrow, 1962; Brau and Fawcett, 2006; Hall and Lerner, 2010; Pollock and Gulati, 2007; Stuart, 2000). For example, an IPO may signal quality and increase a firm's ability to collaborate with other firms possessing research, manufacturing, and regulatory expertise. At the same time, other studies suggest that such a financial structure may disrupts a firm's innovative productivity by exacerbating agency frictions, reducing risk tolerance, increasing short-termism, or causing organizational changes (Berle and Means, 1932; Holmström, 1989, 1999; Meckling and Jensen, 1976; Stein, 1989; Stuart and Sorenson, 2003; Wu, 2012). A large literature has examined this trade-off in cross-industry studies by examining how public markets shape patenting, an early-stage measure of research effort. In general, researchers have found that going public is associated with an aggregate decline in subsequent patenting activity (e.g., Aggarwal and Hsu, 2014; Bernstein, 2015; Dambra and Gustafson, 2021). We shed light on an important, but relatively understudied, question: How does going public shape access to firms' financial and strategic resources throughout the multi-stage process of new product development?

In this paper, we tackle this question by relying on unique features of the drug development industry. To examine how going public shapes firms' product development decisions, we track firms' research activity across the development process, from early-stage trials to drug approvals. Detailed data on diseases allow us to characterize whether an IPO leads firms to explore new disease product markets or focus on previously studied diseases. A further contribution is that we are able to examine firms' collaborative efforts with other firms and their hiring of researcher personnnel following an IPO. A key challenge for an analysis of this type is determining an appropriate counterfactual for the firm's innovation activity had it not gone public. We look at the set of private firms that file for an IPO with the Securities and Exchange Commission (SEC); we consider those that then withdraw the filing and remain private as controls for those that complete the IPO and go public (Bernstein, 2015). Using the drug development data, this counterfactual sample, and a difference-in-differences research design, we estimate the causal effect of an IPO on a firm's product development decisions.

We find that IPOs have important impacts to pharmaceutical firms' R&D decisions. We observe increased research activity for firms with completed IPOs relative to those without across the

development process. In particular, an IPO increases the likelihood that a firm initiates any clinical research investment by 25 percent. Examining how firms shift the direction of their innovative activity, we find that, following an IPO, firms are more likely to expand research efforts in diseases already in their R&D pipelines rather than explore different disease categories or pursue novel mechanisms of action. We also find evidence of higher-quality clinical trials post-IPO.

To understand how the increased research activity we observe post-IPO may be driven by specific firm types, we conduct additional triple differences analyses exploiting variation in firm size. We show that the rise in product development is driven by small firms, with small firms more than twice as likely to initiate a clinical trial relative to large ones. Further, we find that small firms are more likely to increase their licensing and hiring efforts post-IPO. These results are consistent with the hypothesis that an IPO increases financial and strategic resources that enable smaller, more financially constrained firms to expand their research efforts after an IPO. Combined, our results point to competing mechanisms underlying the potential impact of an IPO on product development: The transition to public ownership brings increased external scrutiny, leading firms to engage in lower-risk activities, but also provides smaller firms with needed resources to pursue R&D efforts.

Our paper makes several contributions to the existing literature. First, we evaluate trends in IPOs over time in the pharmaceutical industry, an important sector for analysis given its high R&D spending, growing level of IPO activity, and value to societal health. Second, the use of clinical trial outcomes allows us to create more precise measures of product direction and progress than available via traditional patent measures. With these measures, we can speak to the theoretical mechanisms underlying the effects we observe, including, for example, increased access to strategic resources. Finally, we provide causal evidence of the impact of an IPO to the rate and direction of subsequent pharmaceutical product development.

The paper proceeds as follows: Section 2 describes the theoretical mechanisms underlying the potential effects an IPO may have on product development. Section 3 gives information on the institutional setting of US pharmaceuticals. Section 4 provides information on our data, sample construction, and descriptive statistics. Section 5 outlines our empirical strategy comparing firms with completed and withdrawn IPOs. Section 6 presents results, and Section 7 concludes.

2 Theoretical background

In this section, we discuss the theoretical mechanisms underlying the varying impacts an IPO may have on a firm's subsequent R&D trajectory. Access to funding is pivotal for R&D efforts, however the directional effect of going public on those efforts is theoretically ambiguous: Through access to external financial markets and new strategic resources, an IPO may increase R&D activity within a firm. Conversely, ensuing organizational change, external stakeholder pressures, and agency issues

from the IPO may contribute instead to decreased R&D activity. We discuss these competing effects below.

R&D efforts often involve substantial time, resources, and risk. An IPO provides an immediate cash infusion and can potentially increase opportunities for future external financing. As such, an IPO may promote a firm's research activities by alleviating financial constraints (Arrow, 1962; Hall and Lerner, 2010). In addition to financial resources, an IPO can also improve a firm's access to strategic resources by signaling the firm's legitimacy and raising its visibility (Brau and Fawcett, 2006; Pollock and Gulati, 2007). Indeed, in a survey of chief financial officers, Brau and Fawcett (2006) find that the primary motivation for going public is to facilitate acquisitions and that "high-tech firms view an IPO more as a strategic reputation-enhancing move than as a financing decision" (p. 400). Prior research has found that access to strategic resources, such as alliance partners, can, in turn, increase a firm's research activities (Stuart, 2000).

An IPO not only provides a firm with access to financial and strategic resources but also can bring about long-term organizational change, including changes to strategy, formal structure, board composition, and employee incentives, and internal policies (Fischer and Pollock, 2004; Stuart and Sorenson, 2003). For example, firms tend to grow substantially following an IPO, which may necessitate different corporate governance structures, and managers at public firms often need board approval for certain activities. Wu (2012) argues that, along with short-term disruptions due to the IPO process, such long-term organizational changes may reduce a firm's innovative productivity.

IPOs also come with external stakeholder pressures. For instance, public firms are subject to greater regulations and disclosure requirements by the SEC. Wu (2012) notes that increased disclosures may lead managers to select projects which maintain steady progress over more innovative ones requiring greater risk. By reducing the tolerance for failure, going public can thus have a negative impact on product development (Ferreira et al., 2014; Manso, 2011). Agency issues due to separate interests of managers and shareholders post-IPO are also a concern (Berle and Means, 1932; Holmström, 1989). Bernstein (2015) discusses two hypotheses that may decrease innovative activities: Under the career concerns hypothesis, managers concerned about investors' perception of their ability leads them to avoid innovation. Under the quiet life hypothesis, as managers' jobs become more secure following an IPO, they become less likely to innovate.

In light of these competing theoretical mechanisms, in subsequent sections, we empirically examine the effects of an IPO on a firm's product development decisions, including the rate, quality, and direction of R&D projects.

3 Setting: Pharmaceuticals

The US pharmaceutical industry, one of the largest sectors in terms of domestic R&D spending, provides a useful setting to examine how public financing influences product development outcomes.[1] Using comprehensive data on project-level investments for pharmaceutical firms, we are able to accurately document how public finance shapes firms' research decisions throughout the R&D process. As described below, the pharmaceutical industry contains a growing level of IPO activity and pharmaceutical product development has important economic and welfare consequences.

In the US, drug development consists of a series of phases: The process typically begins with extensive preclinical laboratory research that involves testing a new drug candidate in animals and human cells. Once complete, drug manufacturers begin the most expensive aspect of drug development: human testing of drugs in a series of clinical trials with costs that increase with each subsequent phase. Drugs that successfully demonstrate safety in Phase I trials proceed to Phase II trials in which their efficacy is tested in a few hundred patients. Phase III is the final stage of pre-market clinical development and involves assessing efficacy in thousands of patients and examining them over a longer period of time. Upon successfully completing the Phase III trials, the sponsor will submit a New Drug Application (NDA) or Biologics License Application (BLA) to the US Food and Drug Administration (FDA) for approval. Once approved, firms may choose to conduct additional safety clinical trials or to seek FDA approval for additional therapeutic uses.

The entire process is long (often lasting between 8 to 12 years), costly (typically costing a manufacturer $300 million to $2.6 billion for the development of a brand new molecule), and risky (only 9 percent of drugs that enter clinical trials ultimately reach the market) (Adams and Brantner, 2006; CSDD, 2014; Danzon and Keuffel, 2014; DiMasi, 2001; DiMasi et al., 2003; Wouters et al., 2020).

4 Data and descriptive statistics

4.1 Drug Development Data

Our drug development information comes from two databases: the Cortellis Competitive Intelligence and Cortellis Competitive Clinical Trials Intelligence databases. The Cortellis Competitive Intelligence database is a comprehensive dataset covering drug development activity for more than 240,000 firms. The database provides detailed information about all drugs in a firm's research portfolio and documents each drug's progression from preclinical development to launch and discontinuation. For each drug, we are able to observe its development stage (e.g., Phase III), start of the development stage (e.g., January 15, 2005), and disease under investigation (e.g., colorectal

[1] The pharmaceutical sector makes up roughly 17 percent of total industrial R&D and 62 percent of industrial R&D with health applications (National Science Foundation and Census Bureau, 2018).

cancer). We supplement this information using detailed clinical trial data from Cortellis Competitive Clinical Trials Intelligence. The Cortellis Competitive Clinical Trials Intelligence database includes over 500,000 global and US-based clinical trials from 24 clinical trial registries around the world. Using this dataset, we incorporate detailed clinical trial characteristics, such as the trial sponsor (e.g., Genentech), trial design (e.g., randomized, double-blind, controlled), and any reported clinical outcomes (e.g., share of patients whose tumors respond to treatment).

To assess how public financing shapes subsequent research quantity, we determine the total level of research projects associated with a given firm in a given year. In particular, we examine the number of research projects in seven development stages: pre-clinical research, Phase I, Phase II, Phase III, and regulatory approval. Next, we go beyond these raw counts by investigating how public financing shapes the composition and quality of subsequent product development. To understand changes in research composition, we look at the extent to which the research projects involve a therapeutic area that the firm has or has not previously investigated.

4.2 IPO Data

We collect IPO data from Standard & Poor's (S&P) Capital IQ, Moody's Zephyr, and the SDC New Issues database (for withdrawals only). We determine, for each firm's IPO, the initial filing date, the offer date, the associated exchange, and, if relevant, the withdrawal date. We incorporate IPO information into our firm-year dataset using both ID-based matching (e.g., using firms' CIK and ISIN keys, when available) and fuzzy matching algorithms. We manually check the matches to ensure their accuracy. We restrict to US exchanges and create a composite IPO value by prioritizing the data sources as follows: Capital IQ, Zephyr, and SDC.

4.3 Firm Sample

To build our final dataset at the firm-year level, we begin with the sample of pharmaceutical and biotechnology firms in the Capital IQ database at any point between 1970 and 2020. We next use a multistep cleaning process to create an unbalanced firm-year panel. First, since related firm entities can have slightly different names in the database, we follow an algorithmic and manual approach to clean and group firm names together. Next, using M&A data from SDC Platinum, we account for firm exits and name changes that occur as a result of mergers and acquisitions. We restrict our sample to the set of firms with initial IPO filing years between 2000 and 2019 and that have at least one clinical trial prior to the IPO filing. Our final dataset results in a sample of 252 firms and 2,357 firm-year observations from 1995 through 2020. We focus on this time period as it allows us sufficient time to examine post-IPO research activity. During this period, there are 229 IPOs.

TABLE 1: SUMMARY STATISTICS. COMPLETED VS. WITHDRAWN IPOS BEFORE IPO

	Completed		Withdrawn		
	Mean	SD	Mean	SD	p-value
	(1)	(2)	(3)	(4)	(5)
Project Investment Levels					
Preclinical Activity	1.17	1.93	1.52	3.45	.1
Phase 1 Trials	.31	.67	.23	.54	.22
Phase 2 Trials	.37	.81	.32	.62	.54
Phase 3 Trials	.1	.44	.12	.44	.74
All Trials	.79	1.24	.69	.89	.41
Drug Approvals	.04	.41	.06	.41	.54
Project Selection					
Trial in Previously Tested 3-Digit MeSH	.54	1.05	.44	.71	.32
Trial in Previously Tested 6-Digit MeSH	.53	1.04	.44	.71	.36
Trial in Novel 3-Digit MeSH	.25	.52	.25	.49	.98
Trial in Novel 6-Digit MeSH	.26	.53	.25	.49	.88
Project Quality and Novelty					
Randomized	.47	.89	.45	.68	.75
Multi-blinding	.38	.8	.3	.67	.33
Controlled	.97	1	.64	.82	.02
Novel Mechanism of Action	.07	.37	.05	.32	.65
Other Research Activities					
Patents	2.36	4.38	1.9	2.29	.28
Product Patents	1.07	3.5	.75	1.54	.34
Deals	.84	1.31	.65	1.07	.15
New Hire Publications	3.17	13.1	1.19	2.25	.11
Incumbent Publications	26.31	150.82	7.13	9.59	.18

NOTES: This table shows research characteristics for firms with completed and withdrawn IPOs before the completed/withdrawn IPO. All variables are measured at the firm-year-level. Column (5) presents p-values from t-tests comparing the difference of means.

4.4 Descriptive Statistics

Table 1 provides firm-year level summary statistics for firms that either completed or withdrew their IPOs, focusing on the period prior to the IPO filing. We find that on average, firms with completed IPOs invested in 1.17 preclinical development projects and initiated 0.8 clinical trials each year. Across our various measures of innovative activity—rate, direction, quality, and novelty—we find little difference between firms with completed and withdrawn IPOs. This descriptive evidence suggests that firms with withdrawn IPOs could potentially serve as a control group for firms with a completed IPO. In Section 5, we examine this further by comparing the time trends in pre-IPO outcomes for both groups of firms.

5 Empirical Strategy

A main challenge in estimating the causal effect of an IPO on a firm's subsequent product development decisions is creating an appropriate counterfactual for the firm's research activity had it not gone public. Because firms endogeneously select into the decision to go public, we cannot simply compare private and public firms. Rather, we follow Bernstein (2015) and look at the set of private firms that file for an IPO with the SEC; those firms that then withdraw the filing and remain private serve as controls for those that complete the IPO and go public.

To estimate firms' product development responses following an IPO, we compare changes in the research activity of treated firms (that have a completed IPO) and control firms (that withdraw the IPO) around the timing of the IPO filing (or announcement). To motivate our empirical strategy, Figure 1 gives the average number of trials among firms with completed and withdrawn IPOs, in the years leading to and following the IPO filing. We notice that mean trials across treated and control firms generally track each other in the years before the IPO filing, offering support that these two groups of firms are comparable.

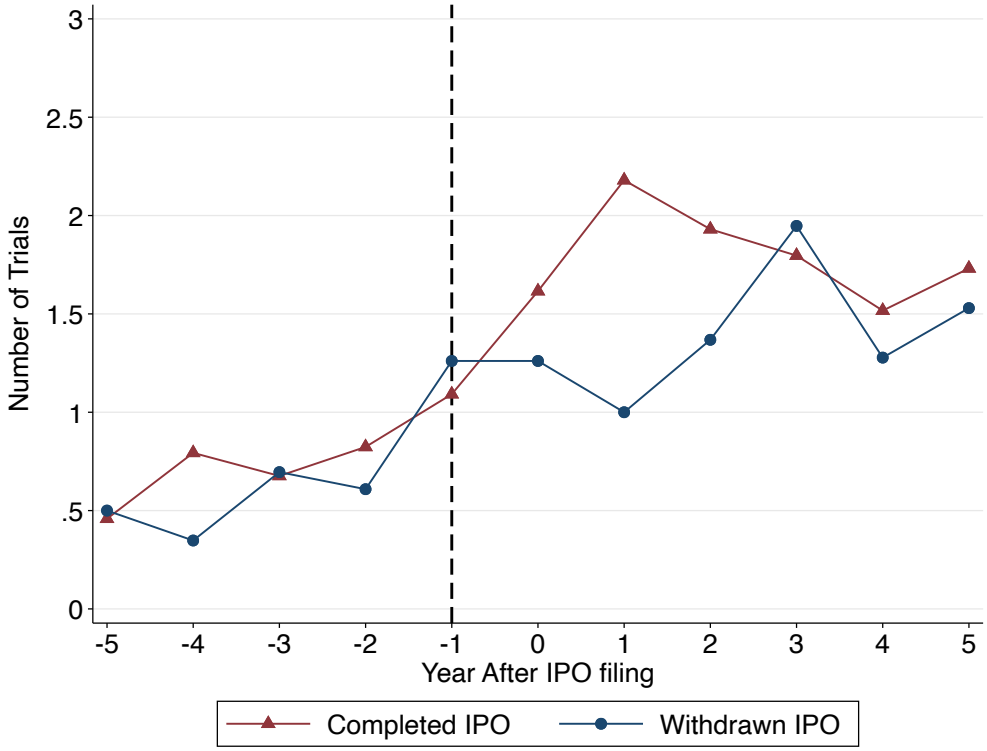
For each firm, we restrict to windows five years before and after the IPO filing and estimate the following difference-in-differences regression for firm i in year t:[2]

$$Y_{it} = \beta Post_t \times IPO_i + \delta_i + \delta_t + \varepsilon_{it} \tag{1}$$

Here, Y is the relevant product development measure; $Post$ specifies the period following an IPO filing; IPO is an indicator for whether the firm is treated or not; δ_i are firm fixed effects; and δ_t are year fixed effects. The coefficient of interest is β, providing the average treatment effect of going public on a firm's product development decisions. We do not include time-varying firm characteristics in the regression as these could themselves be affected by the IPO event and would prevent a consistent estimate of β (Gormley and Matsa, 2011). For instance, any changes to R&D expenditures following an IPO event are likely due to the IPO event and thus part of the treatment effect we wish to capture. If we included R&D expenditures as a control in the regression, β would then only measure the portion of the IPO effect that is uncorrelated with the causal impact of the IPO on R&D expenses. We use robust standard errors clustered at the firm level.

[2]Recent papers have highlighted concerns with such two-way fixed (TWFE) estimators (e.g., Callaway and Sant'Anna, 2021; de Chaisemartin and d'Haultfoeuille, 2020; Goodman-Bacon, 2021). In light of these, we are currently conducting several robustness checks, for example, making use of solely the sample of firms with completed IPOs and the use of "stacked" regressions.

FIGURE 1. CLINICAL TRIALS AMONG FIRMS WITH COMPLETED AND WITHDRAWN IPOS



NOTES: This figure reports the average number of trials among firms with completed and withdrawn IPOs, in the years leading to and following a completed or withdrawn IPO.

6 Results

6.1 The Effect on Project Investment Levels

Table 2 reports the effect of going public on the level of innovative activity, across different stages of the drug development process. Columns (1)–(5), respectively, ask whether going public leads to an impact on the likelihood that a firm initiates investment in preclinical research, a phase I trial, a phase II trial, a phase III trial, any trial (regardless of phase), and any drug approval. Across nearly all stages of the drug development process, we observe a positive and statistically significant impact of going public on the level of subsequent innovative activity. The estimated coefficient of 0.131 in Column (1) suggests a 25 percent increase in the likelihood of a preclinical research investment following a firm's initial public offering. This increase also extends to clinical research: The estimated coefficient of 0.141 in Column (5) indicates that an IPO increases the likelihood that a firm initiates clinical research investment by 24 percent. We document similar results when examining the impact of going public on the number of research investments (Appendix Table A1).

The increase in product development efforts is consistent with Wu (2012), who finds that following an IPO, medical device firms increase their FDA applications.

Notably, we find little impact on firms' patenting activities within our sample of firms (Appendix Table A2). These results are consistent with the view that investments in patenting may reflect both innovative and strategic activities. For example, firms may patent to signal their quality to venture capital investors. However, after going public, firms may find less reason to invest in such activities, leading to a decline in their strategic patenting efforts.

TABLE 2: EFFECT OF AN IPO ON PROJECT INVESTMENT LEVELS

	Any Preclinical Activity (1)	Any Phase I Trial (2)	Any Phase II Trial (3)	Any Phase III Trial (4)	Any Trial (5)	Any Drug Approval (6)
Post×IPO	0.131***	0.0374	0.131***	0.130***	0.141***	0.0569**
	(0.0357)	(0.0323)	(0.0385)	(0.0306)	(0.0378)	(0.0220)
Mean of Dep. Var.	0.527	0.283	0.340	0.174	0.577	0.095
Observations	2,357	2,357	2,357	2,357	2,357	2,357
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

NOTES: This table reports DiD estimates of the effect of going public on the level of innovative activity, across different stages of the drug development process. Observations are at the firm-year level. Estimates are from OLS models. The dependent variable in each column is an indicator for research activity in each stage of the drug development process. *Post×IPO* switches from 0 to 1 when a firm completes an IPO. All columns include year fixed effects and firm fixed effects. Robust standard errors, clustered at the firm level, are shown in parentheses. *p <0.10; **p <0.05; ***p <0.01.

6.2 The Effect on Project Selection

In Table 3, we examine how firms shift the direction of their innovative activity following their IPOs. To do this, we categorize firms' clinical trial activity into two groups: (1) trials targeting diseases already tested by drugs in the firm's R&D pipeline and (2) trials targeting diseases not already tested by drugs in the R&D pipeline. We use Medical Subject Heading (MeSH) codes, a hierarchical controlled vocabulary maintained by the National Library of Medicine, to categorize diseases. We consider two levels of disease similarity: trials within the same 3-digit MeSH code (representing broader disease categories, such as respiratory tract diseases or eye diseases) and trials within the same 6-digit MeSH code (for more narrow disease conditions, such as lung diseases or eye infections). Columns (1) and (2) of Table 3 show that the post-IPO increase in research activity documented in Table 2 is largely driven by investment in diseases that firms have previously researched. In contrast, Columns (3) and (4) indicate that firms are unlikely to expand their R&D efforts to include diseases they have not explored before. Taken together, these findings indicate that following an IPO, firms increase their research in familiar domains rather than exploring new ones.

Table 3: Effect of an IPO on Project Selection

	Any Trial in Disease Previously in Firm's R&D Pipeline		Any Trial in Disease Novel to Firm's R&D Pipeline	
	Same 3-Digit MeSH (1)	Same 6-Digit MeSH (2)	Different 3-Digit MeSH (3)	Different 6-Digit MeSH (4)
Post×IPO	0.158***	0.157***	0.0563	0.0561
	(0.0340)	(0.0341)	(0.0367)	(0.0367)
Mean of Dep. Var.	0.470	0.466	0.252	0.263
Observations	2,357	2,357	2,357	2,357
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: This table reports DiD estimates of the effect of going public on the direction of innovative activity. Observations are at the firm-year level. Estimates are from OLS models. The dependent variable in each column is an indicator for research activity in either the same or different MeSH codes as a firm's existing R&D pipeline. *Post×IPO* switches from 0 to 1 when a firm completes an IPO. All columns include year fixed effects and firm fixed effects. Robust standard errors, clustered at the firm level, are shown in parentheses. *p <0.10; **p <0.05; ***p <0.01.

6.3 The Effect on Project Quality and Novelty

Table 4 probes the effect of going public on the quality and novelty of subsequent R&D activity. The design of a clinical trial plays an important role in shaping the quality of the information generated, with better-designed trials often providing more reliable evidence of a drug's safety and efficacy. For example, patient randomization, in which participants are assigned to treatment and control arms, helps minimize patient selection biases. Columns (1) and (2) of Table 4 show that an IPO increases firm investment in trials that are randomized and blinded. In contrast, Column (3) shows little impact on the likelihood that a trial includes a control group. Further, Column (4) examines whether an IPO changes the likelihood that a firm conducts a trial on drugs with novel mechanisms of action. Consistent with our findings in Table 3 that firms are less likely to engage in different therapeutic domains post-IPO, we observe little effect on the likelihood that firms clinically test drugs with novel mechanisms of action.

Table 4: Effect of an IPO on Project Quality and Novelty

	(1) Any Randomized Trial	(2) Any Blinded Trial	(3) Any Controlled Trial	(4) Any Trial with Novel MOA
Post×IPO	0.168***	0.118***	-0.0217	0.00287
	(0.0394)	(0.0350)	(0.0283)	(0.0163)
Mean of Dep. Var.	0.441	0.331	0.796	0.052
Observations	2,357	2,357	2,357	2,357
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: This table reports DiD estimates of the effect of going public on the quality and novelty of innovative activity. Observations are at the firm-year level. Estimates are from OLS models. The dependent variable in each column is an indicator for measures of either quality or novelty in clinical trial activity. *Post×IPO* switches from 0 to 1 when a firm completes an IPO. All columns include year fixed effects and firm fixed effects. Robust standard errors, clustered at the firm level, are shown in parentheses. *p <0.10; **p <0.05; ***p <0.01.

6.4 Heterogeneity by Firm Size

To investigate the types of firms driving the increases in R&D activity, we examine whether small firms experience a larger post-IPO increase in the level of clinical trials. We categorize firms into two mutually exclusive groups: small firms and large firms, as proxied by firms with below- vs. above-median numbers of patents in the five years prior to IPO filing. The estimated coefficients in Table 5 suggest that the increase in R&D activity is driven by smaller firms: Interpreting the 0.214 coefficient in Column (1) suggests that small firms are more than twice as likely to initiate a clinical trial following an IPO relative to large firms. This result is consistent with the idea that an IPO leads to an increase in financial and strategic resources that enables smaller, more financially constrained firms to expand their research efforts post-IPO.

TABLE 5: HETEROGENEITY BY FIRM SIZE

Dependent Variable:	Any Trial (1)	ihs(Number of Trials) (2)
Post×*IPO*	0.114***	0.282***
	(0.0427)	(0.0695)
Post×*IPO*×*Small Firm*	0.214**	0.279*
	(0.101)	(0.155)
Post×*Small Firm*	-0.200**	-0.279**
	(0.0879)	(0.134)
Mean of Dep. Var.	0.577	0.801
Observations	2,357	2,357
Firm FE	Yes	Yes
Year FE	Yes	Yes

NOTES: This table reports DiD estimates of the effect of going public on clinical trial activity, by firm size. Observations are at the firm-year level. Estimates are from OLS models. The dependent variable in Column (1) is an indicator for any clinical trial activity and the dependent variable in Column (2) is the inverse hyperbolic sine of the number of trials. *Post*×*IPO* switches from 0 to 1 when a firm completes an IPO. *Small Firm* is an indicator for whether the firm's cumulative number of patents in the 5 years before its IPO is above the median. All columns include year fixed effects and firm fixed effects. Robust standard errors, clustered at the firm level, are shown in parentheses. *p <0.10; **p <0.05; ***p <0.01.

6.5 Mechanisms: The Effect on Licensing and Hiring

To explore the potential mechanisms driving the increase in product development post-IPO, Table 6 reports the effect of an IPO on firms' licensing and hiring activities. Motivated by our findings in Table 5, we examine the differences across small and large firms. Column (1) confirms that small firms are more likely to increase their licensing efforts after an IPO. To examine shifts in hiring patterns, we include data on researchers associated with a firm by analyzing their publications.[3] We categorize a publication as being associated with a new hire or an incumbent researcher, defining a new hire as a researcher who has been with the focal firm for two years or less. Columns (2) and (3) indicate that IPOs are associated with increased research activity among new hires, while there is little change in research activity among incumbent researchers. These results are consistent with the view that the increase in product development is partly due to enhanced access to strategic resources, such as licensing opportunities and skilled personnel.

[3]We are currently incorporating data from Revelio, which will allow us to directly examine hiring patterns using information from LinkedIn.

Table 6: Effect of an IPO on Licensing and Hiring

Dependent Variable:	Any Licensing Deal (1)	Any New Hire Publication (2)	Any Incumbent Publication (3)
Post×IPO	0.0227	-0.0448	0.0158
	(0.0418)	(0.0334)	(0.0226)
Post×IPO×Small Firm	0.179**	0.186**	-0.0500
	(0.0880)	(0.0720)	(0.0688)
Post×Small Firm	-0.172**	-0.127**	0.0918
	(0.0764)	(0.0626)	(0.0621)
Mean of Dep. Var.	0.441	0.319	0.566
Observations	2,357	2,357	2,357
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: This table reports DiD estimates of the effect of going public on licensing and hiring. Observations are at the firm-year level. Estimates are from OLS models. The dependent variable in Column (1) is an indicator for any licensing deal, the dependent variable in Column (2) is an indicator for any publication associated with a new hire, and the dependent variable in Column (3) is an indicator for any publication associated with an incumbent researcher. *Post×IPO* switches from 0 to 1 when a firm completes an IPO. *Small Firm* is an indicator for whether the firms' cumulative number of patents in the 5 years before its IPO is above the median. All columns include year fixed effects and firm fixed effects. Robust standard errors, clustered at the firm level, are shown in parentheses. *p <0.10; **p <0.05; ***p <0.01.

7 Conclusion

This paper shows that IPOs have important effects on subsequent product development. Focusing on project investment decisions in the pharmaceutical industry, we show that firms transitioning to public ownership increase their drug development investments by 25 percent. Further analysis of detailed drug development data shows that this increase is driven by high-quality projects.

The implications of these findings extend to both policymakers, managers, and researchers that must consider the advantages and costs of going public. Prior analyses that examine the impact of an IPO on innovation by studying post-IPO changes in firm patenting activity may overlook the strategic role that patents play in signaling quality to external parties—a strategic tool employed by private-sector firms. This study highlights the importance of clarifying the innovative and strategic dimensions of research investments when evaluating the consequences of IPOs on subsequent product development.

Furthermore, we clarify the types of firms and projects most affected by an IPO. We observe that the increase in project investment is concentrated among firms that are smaller (and more likely to be previously facing financial constraints), suggesting that the effect of IPOs on product development

is largely influenced by enhanced access to important resources. However, the transition to public ownership brings increased external scrutiny, leading firms to engage in lower-risk activities. We document that post-IPO, firms concentrate their research efforts in existing areas within their R&D pipelines rather than exploring new diseases or technologies. Taken together, this paper highlights the nuanced relationship between IPOs and firms' product development efforts, shedding light on the strategic balance that newly public firms must play in leveraging new resources for product development and navigating the additional demands that come with public ownership.

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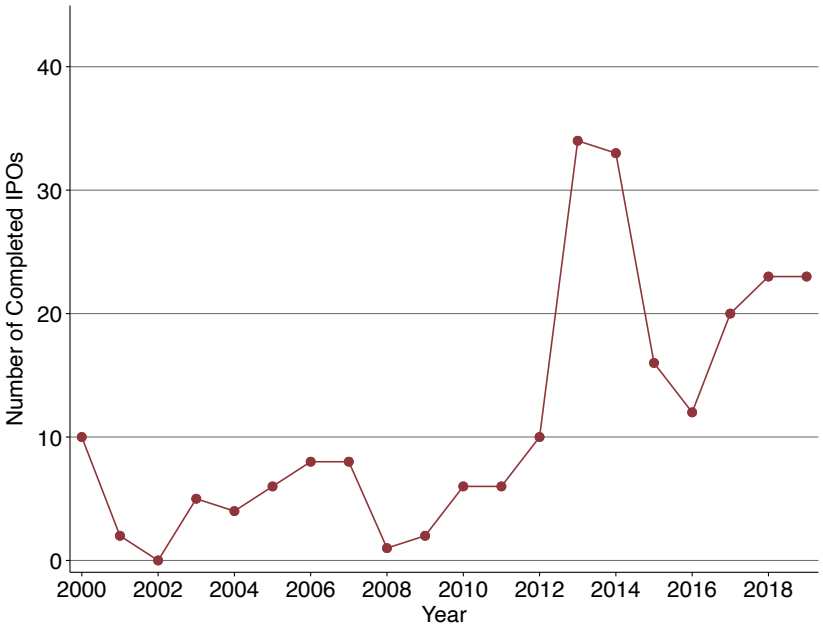
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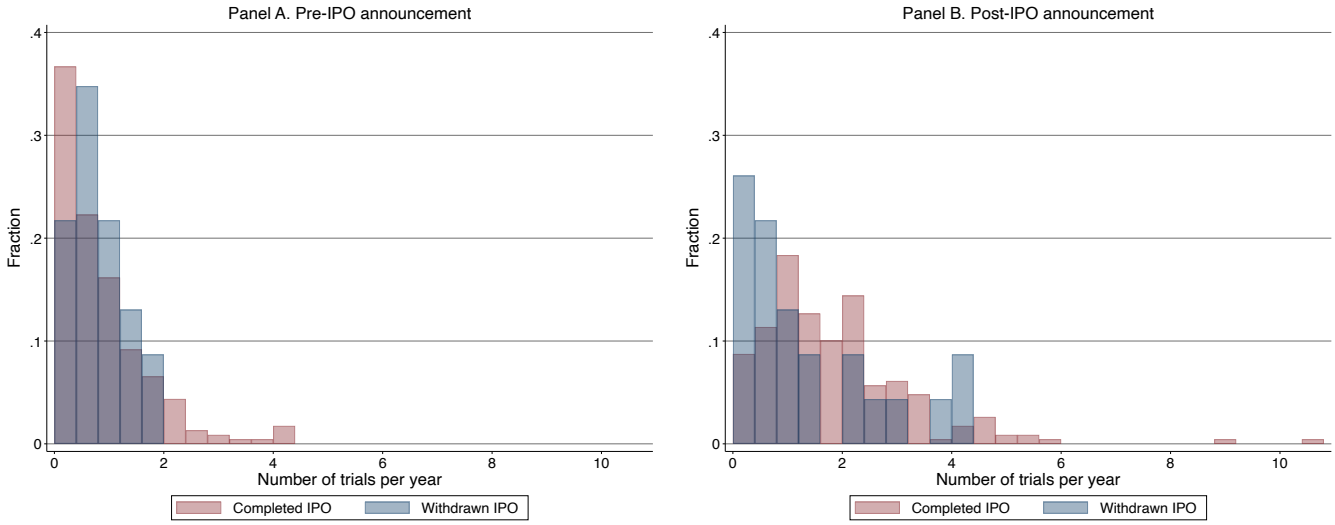
Appendix

FIGURE A1. COMPLETED IPOS OVER TIME



NOTES. This figure reports the number of completed IPOs among pharmaceutical firms in our sample from 2000 to 2019.

FIGURE A2. CLINICAL TRIALS AMONG FIRMS WITH COMPLETED AND WITHDRAWN IPOS



NOTES. This figure reports the average number of trials per year among firms with completed and withdrawn IPOs. Panel A gives average trials pre-IPO announcement, and Panel B gives average trials post-IPO announcement. Observations are at the firm-year level.

Table A1: Impact on Project Investment Levels. Inverse Hyperbolic Sine Transformation

	ihs(Preclinical) (1)	ihs(Phase I Trials) (2)	ihs(Phase II Trials) (3)	ihs(Phase III Trials) (4)	ihs(Total Trials) (5)	ihs(Drug Approvals) (6)
Post×IPO	0.228***	0.0856**	0.167***	0.163***	0.312***	0.0842**
	(0.0602)	(0.0394)	(0.0511)	(0.0376)	(0.0607)	(0.0350)
Mean of Dep. Var.	0.820	0.326	0.398	0.202	0.801	0.139
Observations	2,357	2,357	2,357	2,357	2,357	2,357
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports DiD estimates of the effect of going public on the level of innovative activity, across different stages of the drug development process. Observations are at the firm-year level. Estimates are from OLS models. The dependent variable in each column is the level of research activity in each stage of the drug development process, transformed with an inverse hyperbolic sine transformation. *Post×IPO* switches from 0 to 1 when a firm completes an IPO. All columns include year fixed effects and firm fixed effects. Robust standard errors, clustered at the firm level, are shown in parentheses. *p <0.10; **p <0.05; ***p <0.01.

Table A2: Effect of an IPO on Patenting

Dependent Variable:	Any Patent (1)	Any Product Patent (2)
Post×Successful IPO	0.0367	-0.00883
	(0.0320)	(0.0260)
Mean of Dep. Var.	0.640	0.338
Observations	2,357	2,357
Firm FE	Yes	Yes
Year FE	Yes	Yes

Notes: This table reports DiD estimates of the effect of going public on patenting. Observations are at the firm-year level. Estimates are from OLS models. The dependent variable in Column (1) is an indicator for any patent and the dependent variable in Column (2) is an indicator for any product patent. *Post×IPO* switches from 0 to 1 when a firm completes an IPO. *Small Firm* is an indicator for whether the firm's cumulative number of patents in the 5 years before its IPO is above the median. All columns include year fixed effects and firm fixed effects. Robust standard errors, clustered at the firm level, are shown in parentheses. *p <0.10; **p <0.05; ***p <0.01.