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Financing and New Product Decisions of Private and Publicly Traded Firms

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We exploit Medicare national coverage reimbursement approvals as a quasi-natural experiment to investigate how the financing decisions of private and publicly traded firms respond to changes in investment opportunities. We find that publicly traded companies increase their external financing, and their subsequent product introductions, by more than private companies in response to national coverage approvals. The primary source of the increased financing is through private equity financing of public firms. We show that the stock characteristics of publicly traded firms, such as liquidity and price informativeness, and product market competition are important factors in explaining their financing advantage. (*JEL* G30, G31, G32)

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We investigate why and how public firms may have a financing advantage over private firms in raising financial capital and the potential sources of this advantage; and whether the financing advantage we document has product market implications. We study external financing patterns by public and private firms in the medical device industry in response to shocks to investment opportunities. The shocks we examine are Medicare national coverage decisions (NCD) affecting certain medical device categories. We document that publicly traded firms have a substantially higher external financing sensitivity than private firms to investment opportunities shocks that stems from an increase in private equity financing (PIPEs – private investment in public equity). The magnitude of the differences in financing we document is quite large: Conditional on observing an external financing transaction, publicly traded firms increase the amount they raise by more than twice as much than privately held firms, after NCD approvals.

We show that publicly traded firms' stock characteristics are important factors in explaining their financing advantage. We document that the financing advantage of public firms is more pronounced when their underlying stock is more liquid and has higher price informativeness. We also show that the differences in financing between public and private firms relate to product market features, such as the type of products introduced by firms, and the product market competitiveness of rival firms.

We show that stock liquidity is important, as offering better *exit liquidity* is one of the key advantages that PIPEs have over private investments in private firms. Private investors may prefer to invest in publicly traded firms through PIPEs as they can liquidate their positions easily. The median time from issuance to registration of these private securities is 29 days in our sample; once registered, they become identical to regular publicly traded equity and can be sold in the public market. Private investments in private firms, on the other hand, typically have to wait for the firm to go public or be acquired to cash out, and this frequently can take years.

We also show that stock price informativeness is important due to a market feedback effect (Chen et al. 2007). Public firms' stock prices provide financiers and managers with a signal that improves their

information about the value of an investment opportunity and therefore allow firms to raise more funds than when such signals are unavailable — as for private firms. Public firms with higher price informativeness have a higher external financing sensitivity, as the signal provided by their stock is more precise.

The third factor that we show is important in understanding the financing advantage of public firms is the novelty of products introduced by firms. Both public and private firms that introduce more novel products increase their external financing after an NCD decision, although the increase in external financing for public firms is much larger. Interestingly, when examining firms whose product introductions consist mostly of modifications to existing products, we find that only publicly traded firms raise additional funds, while private firms do not. Examining the product introduction decisions themselves following NCD approvals we find collaborating evidence: Public firms increase their introduction of both types of products (novels and modifications), while private firms only do so modestly for more novel products.

The product modification results are consistent with a winner-take-all effect: Firms that modify products and introduce them first to the market take full advantage of the investment opportunity, while latecomers do not. Modifying existing products requires raising funds quickly, a factor that both PIPEs and private investments in private firms can deliver well. Notably, profits from product modifications are also likely to be realized soon. Thus, investments that provide a better exit strategy, such as PIPEs, are highly attractive to fund this type of investment opportunities. This, in turn, leads to public firms capturing the largest share of investment opportunities resulting from product modifications. For more novel product introductions, the relative financing advantage of publicly traded firms is lower, as the horizon of the payback to investors is longer and thus exit liquidity provided by PIPEs is less relevant.

We examine more extensively the interaction between financing and firms' competitive strength by studying whether the financing advantage of (single-segment) public firms is, in turn, affected by the strength of their rivals. We use the fraction of publicly traded firms operating in a product category as a measure of competitor strength: Public firms are strong competitors, since (as we show) they can react more

strongly to investment opportunities by using external financing. We find that the financing advantage of single-segment public firms is smaller in product categories with a larger fraction of public firms. Thus, while being publicly traded provides a financing advantage, the magnitude of this advantage decreases with the strength of competitors. This result further highlights the importance of the role of ownership in firms' ability to capture the benefits of an investment opportunity.

Our setting allows us to carefully examine the differences in external financing between public and private firms. One benefit of studying the medical device industry is that the scale of operation of most private and public companies is small, with approximately 75% of firms specializing in a single product category. Focusing on single-segment firms is important, as we can isolate external financing transactions from within-firm lending through internal capital markets. An additional interesting feature of this industry is that it has traditionally relied heavily on external financing, and that this external financing is provided almost exclusively by financial institutions. Small companies typically do not require the financial backing of large corporations to develop their products, as the lifecycle of products is much shorter than in other similar medical industries (e.g. the pharmaceutical and biotechnology industries). This feature allows us to study the effect of investment opportunities on external financing more precisely than in other settings.

Importantly, the medical device industry provides us with a quasi-natural experiment. We study firms' financing in the medical device industry before and after Medicare approvals of national coverage reimbursements for medical devices. NCDs occurred in seven out of the nineteen FDA product categories during our sample period, 1998-2010. Our setting contains public and private firms in the *treated* and *control* categories. Our identification comes from a triple-difference strategy: Public versus private; treated versus control categories; and time differences (i.e., before and after NCD shocks).

We address the potential endogeneity of firms' trading status using several approaches. We first show that our results are not driven by differences in firms' observables. We present estimations for three matched samples based on firms' products, productivity and size. We find similar results in the matched samples as

in the main sample. In addition, we compare public firms to a subset of private firms financially backed by financial institutions. Prior papers have shown that private firms receiving financial backing from equity investors are closer in several dimensions, such as ownership, board of directors and professionalization, to publicly traded firms (Baker and Gompers 2003; Lerner 1995; Hellman and Puri 2002; Suchard 2009). We also find similar results when comparing private firms backed by financial institutions to public firms.

Next, we examine whether potential cross-sectional unobserved heterogeneity could by driving our results. We compare a subsample of firms that attempted an IPO to a subsample of firms that did not attempt to change their trading status during the sample period. To the extent that firms that try to change their trading status are somewhat different in unobserved dimensions to firms that do not, we would expect very different external financing sensitivities between these subsamples. However, we find similar results across subsamples, suggesting that cross-sectional unobserved heterogeneity is not driving our results.

Finally, we explore the possibility that time-variant unobserved heterogeneity could affect our findings. That is, that private firms transitioning to public status change in unobservable ways during the transition years and this may be driving the differences in external financing sensitivity we find. To address this, we extend Bernstein's (2015) IV approach and apply it to our setting. Bernstein (2015) considers a sample of firms that attempted an IPO — some firms completed the IPO successfully and others were canceled — and instruments firms' trading status using the 2-month Nasdaq return firms face upon their IPO filling. As our key coefficient of interest is the interaction of a firms' trading status with time-varying investment opportunity shocks, we use as instruments the interaction of time-varying covariates (including firms' characteristics and investment opportunity shocks) and the 2-month Nasdaq return.[1] Our IV results show even sharper differences in financing sensitivities between public and private firms. Thus, to the extent that

[1] References on using interactions between covariates and an instrument as additional instruments can be found in Angrist and Pischke (2009), chapter 4.

the direction of the IV estimates is informative, our results suggest that the differences in external financing sensitivity are not driven by selection.

Our paper makes multiple contributions to the existing literature. First, we are the first to show that publicly traded firms have a financing advantage in responding to investment opportunity shocks. Prior papers focus on public and private firms' financing differences (Brav (2009), Pagano et al (1998), Schenone (2010), Saunders and Steffens (2011)), but do not study differences in external financing sensitivities. By looking at external financing responses to positive investment opportunity shocks, we study whether public firms underlying financing advantage benefit firms, in spite of potentially larger agency conflicts that may lead public firm managers to under-invest as in Sheen (2009) and Asker et al. (2015). Our empirical setting allows us to shed new light on how the financing advantage of publicly traded firms operates: It increases the relative value of being publicly traded when good investment opportunities arise — acting like a real option. Thus, our evidence is consistent with the advantages of being publicly traded outweighing the costs in highly competitive, somewhat opaque industries when firms need external funds to quickly exploit new investment opportunities.

Second, we are the first to show a financing advantage that comes from the private equity channel. Prior papers focus on debt financing differences between public and private firms. One exception is Brav (2009) who considers differences in equity financing for UK firms. However, he does not distinguish the source of equity. Importantly, in the UK private equity financing for publicly traded firms has been extremely uncommon (Hamilton and Newton (2009)), thus Brav essentially compares public equity financing by public firms to private equity financing by private firms. Brav also does not examine financing decisions in response to economic shocks. We are the first to show that PIPE financing plays a significant role in the financing advantage of publicly traded firms over private firms in response to shocks – despite both having access to private financing.

Third, and perhaps most importantly, we are the first to show how this financing advantage operates. We show that publicly traded firms' stock characteristics, such as liquidity and price informativeness, are important factors in explaining publicly traded firms' financing advantage. We are also the first to show that the novelty of a firms' products and product market competitiveness are relevant factors in understanding when the financing advantage has a stronger effect. Incorporating these features of how the financing advantage operates is important, since they are key to understanding how firms make investment and financing decisions.

In a broader context, this paper contributes to the emerging literature that compares privately held and publicly traded firms. Other papers have studied investment and merger decision differences between public and private firms (Gilje and Taillard (2016); Asker, Farre-Mensa and Lundquist (2015); Sheen (2009); and Maksimovic, Phillips and Yang (2013)), differences in CEO pay (Gao and Li (2015)); differences in cash holdings (Gao, Harford and Li (2013)), differences in dividend policy (Michaely and Roberts (2012)), and differences in innovative behavior (Bernstein (2015)). Our paper is the first to study differences in external financing sensitivities, emphasizing how and why the financing advantage is effective.

Finally, our paper also contributes to the PIPE literature. Prior work in this literature has emphasized PIPE investments as investments of last resort (e.g., Brophy et al 2009). However, nowadays PIPE investments are commonly used to fund investment opportunities, and the results of our paper are in line with how this market has evolved. Private equity financing is of particular relevance for a broad variety of industries in which debt financing is modest, due to the risk of their investments, or low asset tangibility (e.g., semiconductors; biotech; medical devices; computer programing; pharmaceuticals). Relatedly, our paper can offer an alternative explanation for the positive announcement return of private equity

investments (see e.g., Chakraborty and Gantchev 2013). PIPEs may allow firms to react fast and efficiently to new investment opportunities.[2]

The rest of the paper is organized as follows. Section 1 provides background on the medical device industry and Medicare NCDs. Section 2 describes the data. Section 3 lays out the empirical methodology. Section 4 presents the baseline results on financing. Section 5 conducts refined estimations that consider matching and an instrumental variables approach. Section 6 explores possible mechanisms behind the main results. Section 7 deals with alternative explanation for our findings. Section 8 concludes.

1. Background of the Medical Device Industry

The medical device industry covers a wide spectrum of products used in the treatment of patients, including cardiovascular devices, dental equipment, ophthalmic devices, orthopedic devices, respiratory devices, surgical equipment, among others. In 2012, this industry had sales of about $350 billion worldwide, with U.S. manufacturers generating 40% of the revenue, and U.S. consumers representing about 30% of the global expenditure on these devices.

From a public opinion perspective (and also from a research perspective), this industry has been overshadowed by the pharmaceutical industry, in spite of not being substantially smaller (its relative size is almost 50% in terms of revenues). Only recently has this industry started to receive substantial media attention, as effective January 1st, 2013, a 2.3% excise tax on medical devices went into effect, as part of a plan to finance the Affordable Care Act.

The medical device industry has several features that makes it an ideal setting to study the differences in financing patterns between privately held and publicly listed firms. First, this industry traditionally has had a low level of industry concentration, with no one firm dominating the industry (see Holtzman 2012).

[2] Papers on PIPE investments, such as Chaplinsky and Haushalter (2010), Brophy et al. (2009) and Gomes and Phillips (2014) do not examine private firms and do not consider responsiveness to shocks.

Small private and public companies are common, and most of them (approximately 75%) specialize in a single product category. Having a large fraction of specialized companies is desirable from the perspective of this study, as internal capital markets considerations are not relevant, thus making it a cleaner setting to study external financing decisions.

Second, while this industry does rely on external financing to develop its products, the product lifecycle is much shorter than in other similar industries (e.g., the pharmaceutical industry). Thus, companies do not typically require the financial backing of large corporations to develop their products. Their financing comes almost exclusively from financial institutions and investors, and not from strategic partners.[3]

1.1. Regulation in the Medical Device Industry

In the U.S., medical devices are regulated by the Food and Drug Administration (FDA). The FDA has two review processes. For medical devices that are classified as *high risk*, a pre-market approval process is required (PMA). This route involves the submission of manufacturing information, preclinical studies and clinical investigations (large randomized studies, as in the pharmaceutical industry, are not usually required). For *medium risk* devices, the FDA typically asks for a 510k submission. In this process, the manufacturer only needs to prove that the device is substantially equivalent to an existing device, in terms of safeness and effectiveness. This process is much shorter than the PMA review, taking less than a year. Importantly, the devices under this modality need to be different from existing devices in some respects (e.g., more accurate, faster, etc.), to avoid violating patent law.[4] However, if a *medium risk* device is not substantially equivalent to an existing device, the PMA process applies. Thus, products that undergo the PMA process are more novel, while products that undergo the 510k process are mostly product

[3] Using Rajan and Zingales (1998) measures of financial dependence, we find that the medical device industry ranks 239th out of 252 industries in financial dependence and 243rd out of 252 in external equity dependence. In comparison, the pharmaceutical industry ranks 250th in both categories. However, the differences in absolute magnitude of the financial dependence measures between these industries are quite large: The measures of financial dependence are two to three times larger for the pharmaceutical industry than for the medical device industry.

[4] See, for example, Sunrise Medical HHG Inc. v. AirSep Corp.

modifications. Approximately 23% of the FDA devices approved are under the PMA modality and 77% under the 510k modality. Some *low risk* devices are exempt from FDA reviews (e.g., a tongue depressor).

1.2. The Role of Medicare in the Medical Device Industry

The bulk of the demand for medical devices in the U.S. comes from the elderly population. Medicare plays a crucial role in how this population is served. Medicare provides nearly universal public health insurance for elderly people (65 years or older), covering about 97% of the senior population in the U.S.[5]

Medicare is composed of four parts: Parts A to D. The program started in 1965 offering only Part A. Part A covers hospital and inpatient services. Part B covers outpatient services, including durable medical device expenses. Part C allows individuals to receive Medicare benefits through a private plan; and Part D — which went into effect in 2006 — provides prescription drug coverage. In 2010, the program expenses were $524 billion, representing approximately 20 percent of total health expenditures, and 3.5 percent of the U.S. Gross Domestic Product (GDP).

Medicare pays for services by reimbursing healthcare providers. Typically, Medicare sets in advance the prospective payment amounts that healthcare providers will receive for services provided to Medicare enrollees.[6] After a service is provided, Medicare's fiscal agents pay the healthcare provider the predetermined rate minus the beneficiary' cost-sharing liability. For Medicare Part B the cost-sharing liability consists of a small deductible and a 20% co-payment (see Finkelstein and McKnight 2008).[7] About 50% of Medicare beneficiaries complement their coverage with other insurance, such as Medigap or health insurance programs provided by their employers (see Card et al. 2008).

[5] To be eligible individuals or their spouses need to have worked 40 quarters or more in covered employment.
[6] These payments differ by region, as costs of service might vary with geographic location.
[7] There is no uniform reimbursement procedure for medical devices. The cost of some devices is reimbursed within a medical procedure, while other devices are reimbursed independently. See How Medicare Pays for Services: an Overview, http://www.medpac.gov

1.3. Medicare Coverage Decisions

The Center for Medicare and Medicare Services (CMS) makes national coverage decisions (NCD) only when it expects a major impact on the program, or when there are cost, quality or safety concerns (see Neumann et al. (2008); and Tunis et al. (2011)). There are three NCD categories: Medical devices, laboratory/diagnostic tests and medical procedures. The request of a national coverage decision can be generated internally by the CMS, or externally by interested parties such as medical associations.[8]

The approval rate after national coverage requests is about 60%, and is similar for externally and internally generated requests (see Neumann et al. 2008). The CMS's statutory directive is to pay for items and services that are "reasonable and necessary." However, what constitutes "reasonable and necessary" has not been clearly defined (Chambers et al. 2012) and the CMS has commented that cost-effectiveness is not a factor in their NCD decisions. Overall, there is consensus among practitioners and experts that there is no clear understanding of what constitutes a good candidate for national coverage approval (see Foote 2002), making the outcome of a NCD request quite unpredictable.

NCD approvals of medical devices can take two forms: Initial coverage of a device for certain medical uses, or the extension of coverage for additional uses of a previously approved device. The approved devices almost invariably need to be FDA approved.[9] The NCD approval for a given device is not limited to a particular manufacturer, but applies to the device itself. All modified versions of a Medicare approved device are covered, conditional on them being approved by the FDA.

Information about NCDs can be found on the CMS website. In the medical device category (i.e., durable medical equipment and prosthetic devices), between 1998 and 2010, the CMS issued seventeen NCD

[8] See http://www.cms.gov/Center/Special-Topic/Medicare-Coverage-Center.html for an overview of the Medicare national coverage decision process and the Medicare coverage database. Only in two cases the NCD decisions were initially proposed by very large medical device companies. These large firms are not in our sample, as we restrict our sample to companies that operate in a single product category with annual sales under $300 million.

[9] Although not an NCD, an exception of CMS' policy of covering only FDA-approved devices was CMS's resolution to give higher coverage to drug-eluting stents (DES) than to regular stents, prior to the FDA approval of DES.

approvals for twelve devices.[10] These devices belong to seven out of the nineteen FDA product categories. There are more approvals than devices, as some devices were subsequently approved for additional uses during the sample period. Table 1 summarizes NCD approvals for 1998-2010. Column I shows the FDA product category of each device. Column II shows the name of the device. Column III shows the year in the sample period in which the device was first approved — or the first year in the sample period the device was approved for additional uses if some initial coverage was approved before 1998. Columns IV and V show the year in which some of the devices were approved for additional uses during the sample period. Column VI shows the year in which the device was initially approved, in case the initial approval was prior to 1998. Table 1, Panel B, shows the product categories that did not receive any NCD approval/extension during the sample period (1998-2010).

TABLE 1

An NCD in a product category acts effectively as a positive shock to the investment opportunities of firms operating in that product category. There are several channels through which this shock can affect firms. First, and most directly, some manufacturers might be producing the approved device at the time of the NCD. Thus, the demand for their devices may improve. Second, even if a manufacturer specialized in a product category (e.g. neurology devices) might not be producing the approved device at the time of the NCD (e.g., deep brain stimulation devices), it is typically the case that the technology it produces is sufficiently related that it can take advantage of the improved investment opportunities to develop the approved device. Third, the increased demand for a particular device may also increase the demand for other related devices in the same category. For example, the increased demand for CPAP machines (anesthesiology devices) also increased the demand for CPAP humidifiers, CPAP gauge manometers for pressure measurement (diagnostics and monitoring), CPAP hoses, etc.

[10] This does not include two NCD approvals of medical devices for their exclusive use in medical trials.

1.4. Economic Relevance of NCDs

In Table 1, Panel C, we present evidence on how NCD approvals affect the returns of public firms, to establish that these approvals are economically significant events. We look at CARs for publicly traded firms operating in product categories affected by NCDs, for different windows surrounding the day when Medicare posts the memorandum with the approval decision. For an event window between -90 to +90 trading days from the memo release, firms display a 21% CAR, on average (statistically significant at the 5% level). For narrower windows, the CAR is smaller. This is to be expected, as the NCD approval memo is usually preceded by a proposed decision memo, days or months prior to the final decision memo. Also, the real implications for medical device manufacturers are not entirely clear until sometime after the memo is released.

In unreported analysis, we replicate the CAR analysis excluding firms that were not producing the NCD approved device prior to the NCD approval. We find that the CAR for those firms is 19% for the (-90, +90) window, and not statistically different from the CAR of firms that were already producing the approved device prior to the NCD approval. This evidence supports the notion that NCDs act effectively as a positive shock to the investment opportunities to all firms operating in that product category, given the strong interrelatedness among devices in a product category.

We complement the evidence on cumulative abnormal returns, with Figure 1. It displays the distribution of entry (firms founded) for product category-years with and without NCD approvals. The Figure shows that a higher proportion of entry occurred in product category-years in which NCDs were approved. In particular, the median number of firms entering in a product-category year with and without an NCD approvals are 3 and 2, respectively. The difference in median number of entrants is statistically different at the 10% level (p-value of 6%). This supports the idea that NCDs also benefit privately held firms. Founded firms always enter the market as privately held, and actually none of the firms that entered during NCD approval years went public during the sample period.

FIGURE 1

To further explore whether private firms could potentially benefit from NCD approvals as much as publicly traded firms, we look at how many public and private firms were producing an NCD-approved device prior to the NCD. Out of the 728 private firms operating in the product categories with NCD approvals during the sample period (see Section 2 for data details), 67 (9.2% of the total) were producing the NCD approved device prior to the NCD approval. Out of the 62 public firms operating in the product categories with NCD approvals during the sample period, 6 (9.7% of the total) were producing the NCD approved device prior to the NCD approval. Thus, there is no apparent difference among public and private firms in terms of how well positioned they are prior to an NCD approval. The fraction of firms already producing the approved device is similar across both groups.

2. Data

We construct our data using five data sources: The Food and Drug Administration (FDA) website, Capital IQ, Hoovers, DealScan and the Harvard Business School (HBS) patent database. Matching firms from these data sources is challenging, as there is no common identifier. Moreover, many companies within the medical device industry have very similar names, making any matching algorithm unviable. Thus, we manually match all datasets using the firms' names and addresses.

From the FDA website we collect information on all companies that have obtained FDA permission to introduce or modify a medical device for use in the United States from 1998 to 2010. We restrict the sample to start in 1998 as we merge this data with Capital IQ transaction data, and 1998 is the first year Capital IQ reports these data comprehensively. In particular, from the FDA website, we obtain the companies' names and the number of approved product introductions and modifications per year (through the PMA and 510k processes). The FDA classifies medical devices into nineteen categories (see Table 1, above). Using these categories we can identify the product line(s) of the medical device companies. We restrict our sample to those companies that operate in a single product category. This allow us to isolate the effect of NCD

approvals — which are specific to a product category — on financing decisions. From Capital IQ we obtain fund raising transactions, such as SEOs, fixed-income offerings, PIPEs, VC, etc. From DealScan we obtain information on bank loans.[11] From the HBS patent database we obtain information on patents granted to firms in our sample.[12]

Ideally, we would like to have information on a firm's assets or sales on a yearly basis. Unfortunately, this information is not available for private firms.[13] Nevertheless, Hoovers and Capital IQ contain information for firms' preceding-year sales, for both private and public companies. Given that we initially downloaded the data in 2012, preceding-year sales are for 2011. Thus we use firms' last year sales as proxy for firm size — in addition to the number of products introduced per year obtained from the FDA website. We exclude companies with missing sales data. We obtain firms' age using the firms' founding years from Capital IQ. We also obtain data on the number of employees in 2011. We use this variable to construct measures of firm productivity: Sales per employee and products introduced per employee.

From Capital IQ, we identify whether a firm is a stand-alone company or a subsidiary. We restrict our sample to U.S. firms that are not operating subsidiaries of other companies, as it is central to our study to isolate external financing activities from internal capital market considerations. We also limit our sample to companies with sales of no more than US$300 million, for two reasons. First, large public companies are typically not comparable to our sample of private companies. Second, large public companies may lobby for the approval of NCDs raising concerns about the exogeneity of NCD approvals on those large firms'

[11] We compare Capital IQ deal coverage with other commonly used datasets, such as Venture Expert and SDC. Capital IQ is as comprehensive as these other databases, with the advantage of containing information on all type of deals — except bank loans — in a single platform. DealScan is the most comprehensive database on bank loans.
[12] See Lai, D' Amour, and Fleming (2011) for a more detailed description of the data. We choose the HBS patent database over the NBER version of the U.S. PTO data, given the HBS database covers all of our sample period.
[13] For a small fraction of private companies (SEC-filing private firms), Capital IQ provides short time series of historical financial data (see Gao and Li (2015) and Gao, Harford and Li (2013)). For the vast majority of the companies in our data this information is not available.

external financing transactions. We exclude 54 firms with more than $300 million in sales given this condition.[14]

Our final data set contains 19,065 firm-year observations for 1,803 companies. Of these, 18,006 observations belonging to 1,728 firms correspond to private firms, and 1,059 observations belonging to 101 firms correspond to publicly traded companies.[15] *Forty-three* percent of the firms (and observations) operate in product categories that received an NCD approval during the sample period (i.e., treated firms). The reminding 57% of the firms (and observations) compose the control group.

2.1. Summary Statistics

Table 2 provides the summary statistics of our sample. *External financing amount* represents the yearly amount of external financing raised by the firms in our sample. If a firm does not raise funds externally in a year, this variable takes a value of zero; if it does, it takes the transaction amount. On average, firms in our sample raise one million dollars a year. *External financing transaction* is an indicator variable that takes a value of one if a firm obtains external financing in a year, and zero otherwise. *Private* is an indicator variable which takes a value of zero if a company was publicly listed in a year, and one otherwise.

TABLE 2

Products per year shows for each firm-year the number of FDA-approved new products and approved modifications to existing products. This variable can be used as a *time-variant* measure of a firm's size, as companies that introduce more new products or propose more modified versions of existing products are also larger. *Products per year* (510k) is the number of FDA-approved products for a firm in a year that are substantially equivalent to other existing products of *medium* risk in the market (i.e., product modifications).

[14] Our results hold if we allow for less stringent cutoffs, e.g. $500 million, $1,000 million, etc. However, introducing larger companies in the sample raises identification concerns, as large companies are more likely to participate in lobbying activities.

[15] The sum of private and public companies is higher than the total, as some companies changed their listing status during the sample period.

Products per year (PMA) is the number of FDA-approved products to a firm in a year that underwent Premarket Approval (i.e., novel devices). On average, a firm introduces 0.3 products through the PMA and 510k processes in a given year. *Sales* is the 2011 sales revenue in millions of dollars. The median (mean) annual sales revenue for a firm in our sample is three (thirteen) million dollars, highlighting the fact that our sample is composed of small public and privately held firms.

The variable *Patent issuer* takes a value of one if a firm has ever been granted a patent during the sample period, and zero otherwise. The fact that almost 40% of the firms in the sample have issued a patent highlights the innovative nature of the industry. The variable *Patents granted per year* indicates the average number of patents introduced in a year by firms in the sample. On average, firms in our sample are granted a patent every five years.

The next two variables are ratios of previously described variables scaled by the number of employees working in a firm: *Products per year/Employee* is the ratio of products introduced/modified by a firm in a given year divided by its 2011 employees; and Sales/Employee represents the 2011 ratio of sales per employee of a firm.

The variable *NCD approval* takes a value of one if a firm operates in product category that received an NCD approval, for the NCD year itself and the next two years, and zero otherwise. We define NCD approval shocks using a three-year window (t=0 to t=+2), as we find that increases in financing activity can last up to two years after an NCD approval.[16] We discuss the timing of financing in more detail in Section 5.

2.2. External Financing Transactions

Table 3, Panel A, shows the transaction types and average dollar value per transaction for the subsample of privately held companies. Venture capital transactions are the most common source of external financing

[16] Alternative definitions of NCD approval shocks yield similar results. In prior versions we defined NCD approvals as permanent shocks, four-year shocks and as one-year shocks, leading to analogous results.

for private companies, representing 66% of the deals. Growth capital transactions are the second-most frequently used source of external financing for privately held firms, representing 28% of the deals. Bank loans are observed less frequently. This is to be expected, as even for public firms the median (mean) industry leverage ratio is just 3% (10%).[17] Debt financing is not very common in this industry, given that investments in medical devices are generally non-collateralizable with assets that represent intangibles including growth opportunities and human capital.

TABLE 3

Table 3 also shows that 29 firms went public during our sample period. Although the IPO transaction is initiated when a firm is privately held, the funds are received by the firm only when it changes its ownership status to publicly traded. Thus, we assign the amount raised through an IPO — and the transaction itself — to the year in which the firm becomes publicly traded and classify this transaction as one by a public company. However, our results are not sensitive to this classification, or to dropping observations for firms that underwent an IPO during the sample period. Notice that while 29 firms going public seems low in comparison to the number of private firms, this number represents a large fraction (40%) of firms that were public at the beginning of the sample (72 firms) — there are 101 public firms by the end of the sample.

Table 3, Panel B, shows the transaction types and average dollar value per transaction for the subsample of publicly traded companies. Private investments in public equity (PIPEs) are the most common source of external financing for publicly traded companies in our sample, representing 64% of the transactions. The fact that 76% of the non-debt transactions (176 out of 232) are done through private markets relates to the small size of public firms in our sample, but it is not unique to this industry. Using a sample that contains all industries, Gomes and Phillips (2012) find that among small public firms, 73% of the non-debt issuance

[17] This information was obtained from Compustat, 2012.

(equity and convertibles) is placed privately. Note that Gomes and Phillips (2012) do not examine security issues by private firms or changes in financing following shocks to investment opportunities.

In Table 3, Panel C, we present information regarding the time from announcement to closing for equity transactions for firms in our sample showing that private offerings can be arranged faster than offerings in public markets.[18] The mean time from announcement to closing for VC, Growth Capital and PIPEs is around 30 days, while for SEOs it is close to 130 days. Despite the similarity in time from announcement to closing for private securities issued by publicly traded firms (PIPEs) and private securities issued by private companies, these securities differ in other important dimensions. PIPEs offer better exit liquidity than private securities, as they are typically registered with the SEC shortly after their issuance. Once registered, the security becomes identical to regular publicly traded equity and can be sold in the public market. The securities can also contain "piggyback" registration rights that require the company to register the securities before selling any other stock. In addition, they can contain penalties in the form of additional stock (payment in kind (PIK)) given to the investors if the company fails to register the equity with the SEC within a given period (see, for example, the PIPE issue of World Heart Corp, Jan 2010).[19] We examine SEC filings for firms that issued PIPEs and identify the exact registration dates. We present this information in Panel C, column II. The mean time from closing to registration for firms in our sample is 126 days. While we do not track the time from closing to possibly exiting a position for private securities in private firms, the usual exit route for investors is that the private firm either becomes public or is acquired, which often takes years.

We complement the evidence on registration dates with evidence on the evolution of shares outstanding for firms that issued PIPEs in our sample. In particular, for each PIPE in the sample we compute the first

[18] The benefits of issuing privately have to be traded off against the price discount at which PIPEs are issued, relative to SEOs.

[19] The PIPE terms can be found in documents filed with the SEC. For example, in an 8-K form (Jan 26th, 2010), World Heart Corp commits to file the registration for the securities within 60 days of the issuance date: http://www.sec.gov/Archives/edgar/data/1024520/000110465910003065/a10-2442_18k.htm
The corresponding 13D schedule — Item 6 —mentions piggy-back registration rights: http://www.sec.gov/Archives/edgar/data/1024520/000119312510022178/dsc13da.htm

difference in shares outstanding between six months after and six months prior to the transaction. We also compute the first differences of this variable for two placebo periods: One year prior and one year after the actual PIPE date. We use these first differences as a control group. We then compute the differences-in-differences for shares outstanding. The results show that shares outstanding increase substantially more around the actual PIPE dates than around placebo dates. The differences-in-differences estimates are statistically significant at the 5% level. This is consistent with PIPE becoming regular equity shares.

Another advantage of PIPEs is that even prior to these securities being registered, private investors can also hedge the price risk in these securities. Investors can sell short the publicly traded equity, prior to the securities being registered, after the details of the securities have been disclosed to the public through a SEC filing (8-K or 13D). Consistent with the notion that PIPE investors diversify their risk, Brophy, Ouimet and Sialm (2009) show that short selling in the public equity of a firm increases after a PIPE transaction. This is also the case in our sample. We perform the same difference-in-difference exercise for short interest (in percentage terms) as for shares outstanding, around PIPE issuances. We also find that short interest increases around PIPE issuance by more than around placebo dates.

3. Baseline Empirical Strategy

To analyze the impact of changes in investment opportunities on external financing decisions we estimate several variations of the following baseline empirical model:

$$(1)\ y_{it} = \alpha + \beta * Private_{it} + \gamma * NCD_{it} + \delta * Priva_{it} * NCD_{it} + \boldsymbol{\Omega'X} + \varphi_i + \mu_t + \varepsilon_{it}$$

The subscript i indexes firms and t indexes years. The dependent variable y_{it} represents either the logarithm of the dollar value of external funds raised in a year, or the indicator variable for an external financing transaction.

The β parameter captures the average differences in external financing between privately held and publicly traded companies. We expect this parameter to be negative as privately held companies typically

obtain external financing less often and in smaller amounts than publicly traded companies (see Brav (2009)). The parameter γ captures the effect of NCD approvals on external financing. As *NCD* represents an increase in investment opportunities, this parameter is expected to be positive: Better investment opportunities should lead to more investment and additional funds may be needed. Our main parameter of interest is δ. This parameter tells us whether private and public companies differ in their sensitivity to investment opportunities. If δ is negative, private companies raise less external financing than publicly traded companies when facing better investment opportunities.

In our setting δ represents the differential treatment on the treated effect of investment on external financing, for public and private firms. That is, our quasi-natural experimental setting allows us to identify the effect of investment opportunities on financing, for both private and public firms, and its difference. Key to estimating the differential treatment on the treated effect is being able to control for other characteristics that may correlate with a firm's trading status. To address this concern, we include a set of controls that contains the number of products introduced in a year — through both 510k and PMA submission processes — to capture differences in firm size and technology. We also include sales revenue to further control for firm size; firm age, as young firms typically require more external financing than mature firms; and measures of firm productivity, such as *Products per year/Employee* and *Sales/Employee*. We estimate our main results using firm fixed-effects, φ_i, to mitigate potential concerns about cross-sectional unobserved heterogeneity.[20] In a nutshell, our identification comes from a triple-difference strategy: Public versus private; treated versus control categories; and time differences.

In all our specifications, we include year fixed-effects, μ_t, to control for unobserved macro shocks that may correlate with financing activities (e.g., aggregate demand shocks, changes in the cost of funds, etc.). In some specifications we estimate non-linear models, such as standard Tobit, or Probit. For these specifications, firm fixed-effects are not included, as their inclusion would lead to inconsistent parameters.

[20] In the fixed-effect specification the coefficients of time-invariant firm characteristics cannot be estimated; however, their interaction with *NCD approval* can be included, since *NCD approval* is time-variant.

In addition, in several specifications we include the interaction of all the controls that correlate with listing status (e.g., age, size, products introduced, etc.) with *NCD Approval* (investment opportunity shock). By including these interactions, we mitigate concerns that differences in external financing sensitivities that we attribute to the trading status may be due to observables that correlate with the trading status itself.

In all specifications we adjust standard errors for heteroscedasticity and product-category clustering. We cluster at the product-category level as demand shocks have effects at this level of aggregation. This clustering strategy accounts for three types of arbitrary correlations in the error term: (1) Error correlation across different firms in a given product line and year; (2) error correlation across different firms in a given product line over time; and (3) error correlation for a given firm over time (see Petersen (2009)).

Our main estimates face two key challenges. We need to show that the results are not driven by prior trends; and we need to address possible selection concerns related to firms' trading status. We address these in Section 5, after presenting our baseline financing results.

4. Baseline Financing Results

4.1. Main Results

Table 4 presents our main regressions examining external financing sensitivity to NCD approvals. Panel A presents regressions examining external financing transaction amounts, and Panel B presents regressions examining the likelihood of an external financing transaction. Specifications shown in column II differ from those in column I in that they also include the interaction of the control variables with the NCD shock.

TABLE 4

All the specifications show similar results: NCD approvals have a strong positive effect on external financing, suggesting that NCD approvals are expected to have an important effect on firms' future demand, and thus firms raise funds to invest and meet market needs accordingly. This result is consistent with the

evidence on CARs and new founded firms we presented in Section 1. More importantly, the coefficient of the interaction between *Private* and *NCD Approval* is negative and statistically significant. That is, publicly traded firms have higher financing sensitivity to improved investment opportunities than privately held firms.[21] This finding is novel to the literature, and it is of particular relevance, as it shows that publicly traded firms raise more funds when needed the most, in spite of potentially larger agency conflicts that may lead to under-investment due to managers' short-termism (Sheen (2009) and Asker et al. (2015)).

While we focus on the interaction between private trading status and the NCD approval, we also show the *Private* indicator variable. Given that we include firm fixed-effects, the coefficient from the *Private* indicator is identified by comparing the 29 firms that underwent an IPO during the period to the firms that did not change their trading status. The coefficient of the dummy *Private* is negative, although not always statistically significant. This suggests that private firms that did an IPO used less financing when they were private than when they became publicly listed.

In column III of Panel A, we present the results from a Tobit estimation, for robustness, as the variable *Log(Ext. fin. amount)* contains an important fraction of observations with zero values (i.e., when no external financing transaction occurred). Also, in column III of Panel B, we replicate the results of the linear probability model on *Ext. fin. transaction* using a Probit model. All results hold.

4.2. Economic Effects

The economic effects of NCD approvals, for public and private firms, are summarized in Table 4, Panel C. We consider the economic effect of an NCD approval from three angles: First, the amount of external funds raised; second, the probability of raising external funds in a year; and third, the amount raised, conditional on observing an external financing transaction in a year. The estimates presented are obtained using the coefficient estimates from Table 4, Panels A and B. The first and the second effects are obtained

[21] The coefficient of the interaction term is negative, in spite of a potential bias in the other direction, given that Gao, Harford and Li (2013) document that public firms hold more cash than privately held firms.

from the linear regressions (Panels A and B, column I), the third effect is computed from the Tobit specification (Panel A, column III).

Our results indicate that for public firms, an NCD approval leads to an 18% unconditional increase in external funds raised, and a 6% increase in the probability of raising funds externally in a year. For private firms, we find no effect: An NCD approval lead neither to an unconditional increase in external funds raised nor to an increase in the probability of raising funds externally in a year. The economic effects for publicly traded firms and the differences between private and public firms are all statistically significant at the 1% level.

One potential caveat in the interpretation of the above results is that Capital IQ or DealScan may register fewer transactions for private firms than for publicly traded firms. If this undersampling was more severe for private firms affected by an NCD approval, this could bias the estimation of the differences in external financing sensitivity of public and private firms. To address this concern, we also present the marginal effect of an NCD approval on the amount raised, conditional on observing an external financing transaction. This estimate can be obtained from the Tobit specification. It is not affected by potential sampling issues, since conditional on a deal being reported, there is no systematic bias in the amounts reported (there is no reason to believe that deal amounts are misreported). The results indicate that conditional on observing an external financing transaction, private firms increase their external financing amount by 4% after an NCD approval, while publicly traded firms increase their external financing amount by 8% — twice as much. As can be seen, even conditioning on observing external financing transactions we find that publicly traded firms respond substantially more to investment opportunities than privately held firms. Thus, the difference in external financing sensitivity we document cannot be attributed to deal reporting issues.

Another potential concern is that by including newly founded private firms in the sample (see Figure 1), which are on average smaller, our estimates could be biasing upward the difference in external financing sensitivity between public and private firms. To explore this possibility we replicate our main results,

excluding firms founded during the sample years. We obtain similar results (reported in the Internet Appendix, Table IA.1). Thus, our results do not seem to be affected by the inclusion of newly founded firms.

5. Parallel Trends, Selection and Financing Alternatives

5.1. Timing of Financing and Parallel Trends

We now study the timing of financing relative to NCD approvals. Doing this is useful for two purposes. First, we can run falsification tests on the parallel trend assumption. We examine whether the difference in external financing between private and public firms is significant in the years prior to an NCD approval. If that is the case, then we cannot rule out that the difference in external financing sensitivity to NCD approvals we find in our main results is simply a consequence of prior ongoing trends. The finding of no significant differential effect in the years prior to an NCD approval, however, would provide support for the parallel trends assumption that we have been implicitly maintaining.

Second, we study the length of the effect of NCD approvals on firms' external financing. Our definition of the *NCD approval* variable assumes that NCD approvals may have an effect on external financing during the NCD approval year and the two following years, as the scope of the investment opportunity may not be fully realized right away. By studying the exact timing of financing we intend to provide further justification for our chosen time window.

We replicate the full-sample firm fixed-effects specification from Table 4, redefining NCD approvals as one-period shocks. The results are shown in Internet Appendix, Table IA.2. Panels A-C show the financing results for three to one years before NCD approvals (e.g., in Panel A the *NCD approval* dummy

takes a value of 1 three years prior to an NCD approval, and 0 otherwise); Panel D shows the results for the NCD approval year; and Panels E-G show the results for one to three years after an NCD approval.[22]

Panels A-C show no significant differential effects in external financing for public and private firms in the years prior to an NCD approval. The coefficients of the *NCD approval* dummy and their interaction terms with the dummy *Private* are not statistically significant. Thus, the parallel trend assumption is supported by the data. Panel D shows that in the NCD year, public firms increase their external financing by more than private firms, and this difference is statistically significant at the 5% level. Panels E and F also show that NCD approvals have important differential effects on financing for public and private firms for the next two years following an NCD approval. Panel G shows that NCD approvals do not have a positive effect on firms' external financing in year t+3. The results from Panels D-F support our choice of defining NCD shocks from time *t* to *t+2* in the main analysis.

5.2. Selection

The decision to become a publicly traded firm is not random. Thus, while δ in equation (1) has a causal interpretation (i.e., the investment opportunity shock causes a larger increase in financing for public firms than for private firms), this does not imply that all the difference in external financing we find can be attributed to the trading status itself. Some of the difference in external financing sensitivities could be due to factors that affect the selection into the publicly traded status. In other words, δ in equation (1) represents the differential treatment on the treated effect, but in order to ascribe the difference in external financing sensitivity to the trading status itself we need to estimate the differential average treatment effect. In what follows, we describe several approaches that help us getting closer to that estimation, including matching, subsample analyses and IV regressions.

[22] To ease the exposition, from this analysis onwards we display the coefficient of the *Private* only when it is relevant to the discussion.

5.2.1. Matching

In Table 5 Panel A, we compare the variable means for privately held and publicly traded companies. The table shows some differences. To mitigate concerns that differences in observables between these groups create a wedge between the differential treatment on the treated effect and the differential average treatment effect, we replicate our estimations (equation (1)) using three matched samples. For each of the matching procedures we match on firms' *sales, age, Products per year (510 k), Products per year (PMA); Products per year/Employee*, and *Sales/Employee*. Matching on sales and age helps capture differences related to firm size and life cycle. Matching on different types of product introduced helps match on technology: Firms producing more PMA products, which are more novel and riskier, may have a different cost structure than firms introducing more products that are substantially equivalent to others through the 510k submission process. Finally, matching on sales per employee and total products introduced per employee helps mitigate concerns regarding differences in productivity, stage of commercialization, and product development.

TABLE 5

Our first procedure matches firm pairs at the beginning of the sample and follows matched pairs through time (similar to Asker et al. 2015 and Gilje and Taillard 2016). We consider publicly traded firms that operate during the thirteen years of the sample and that did not change their trading status during that period (i.e., excluding IPO firms). This leaves us with 60 firms. We match them to private firms that also operated during all thirteen years. We use propensity score matching based on 1998 characteristics. We lose fourteen public firms, as there were no private firms with common support in the distribution. Our final sample consists of 46 matched pairs that operate through the whole sample period. The univariate differences for this subsample in the year of the match are presented in Table 5, Panel B.

Our second procedure matches public to private firms within product categories. For the treated categories, we match public to private firms in the year prior to the treatment (first treatment, if there were

two or more) and track the matched pairs through time. For product categories that did not receive an NCD approval (i.e., control categories), we simply match at the observation (firm-year) level. For both treated and control categories we use propensity-score matching. This matching procedure is quite demanding, as for each observation we need to find a suitable match, based on six observable characteristics within a product category. As a consequence, for several publicly traded firms there is no match with common support in the distribution. Our matched sample of treated firms consists of nineteen public firms (237 obs.) and nineteen private firms (237 obs.). Our matched sample of control firms consists of 40 public firms (331 obs.) and 135 private firms (331 obs.). The univariate differences for this matched sample are presented in Table 5, Panel C.

Our third procedure simply matches public firm-years to private firm-years. This type of matching maximizes accuracy, at the cost of not following firms through time or matching within product categories. The univariate differences for this matched sample are presented in Table 5, Panel D.[23] In all three matched samples, the observable differences between groups are greatly reduced relative to the overall sample.

In Table 6 we replicate our main results using the three matched samples. As different matching procedures do a better job at matching different variables, showing consistent results across all matched samples ensures that differences in our estimates are not driven by differences in observables. Panel A presents regressions examining external financing transactions amounts, and Panel B presents regressions examining the likelihood of an external financing transaction. Columns I, II and III present the results for the samples matched on initial observations, within product categories, and at the firm-year (observation) level, respectively. All specifications consistently show that publicly traded firms have a higher external financing sensitivity to investment opportunities than privately held firms.

[23] For the three matched samples we use exact pairs considering a caliper of 0.001 and drop observations with no common support in the distributions. We use sampling without replacement to avoid biasing the standard errors in the econometric analyses we perform. However, all our results hold when matching with replacement.

TABLE 6

5.2.2. Comparing Public to VC-backed private firms

Public and private firms may also differ in dimensions unobservable to the econometrician. For instance, public and private firms may differ in their expertise in raising capital. Perhaps only those private firms that have prior experience raising funds from financial institutions are comparable to public firms. Prior papers have shown that private firms receiving financial backing from equity investors are not only closer to public firms in their experience raising funds, but also in several other dimensions, such as ownership structure, board of directors composition and professionalization (e.g., Baker and Gompers 2003; Lerner 1995; Hellman and Puri 2002; Suchard 2009). Thus, to assess whether potential differences in those dimensions could be driving our results, rather than the trading status itself, we repeat our main analysis comparing publicly traded firms to a subset of private firms that have been previously backed by a financial institution.

Specifically, we search in Capital IQ for private firms that have registered the presence of a previous investor, or for which there is a record of a prior financial investment by a financial institution. We find that for 3,784 private firm observations (belonging to 489 private firms) there is a record of a prior investment by a financial institution. For this subsample of private firm observations we observe external financing transactions for 18% of the observations (three times higher than for the overall sample of private firms).

We present the results comparing public firms to the subset of privately held firm observations in column IV of Table 6. The results are virtually unaltered relative to those presented in the main results. Thus, it seems unlikely that unobserved differences in dimensions such as financial experience or professionalization are driving our results. [24]

[24] Another benefit of using the subsample of financially backed private firms is that it is free from potential under sampling concerns regarding private firms' financing transactions: Once Capital IQ registers a transaction for a firm it usually registers all subsequent transactions.

5.2.3. Selection Based on Unobservables

So far, we use two methods to address possible selection bias: (1) We use matched samples to mitigate selection concerns based on observables; and (2) we explore whether our results hold when focusing on a subset of private firms that it is likely closer to public firms in certain unobservables, such as financial experience and professionalization. To the extent that results are consistent across matched samples and subsamples, the differential treatment on the treated effect and the differential average treatment effect are likely similar.

However, other types of unobserved heterogeneity could still raise concerns. Suppose that firms that choose to go public and those that choose to stay private differ cross-sectionally in some unobserved factor that does not correlate strongly with the variables we use in our matching procedure, or with factors that motivate our subsample analysis. If this is the case, it is possible that the differential treatment on the treated effect may be different from the differential average treatment effect, even if the matched sample and subsample results are similar from those obtained using the main specification. This, in turn, could preclude us from attributing the differences in external financing sensitivity to firms' trading status.

We address this concern by replicating our estimations using a subsample of firms that attempt to transition from private to public status, and comparing it to the subsample of firms that did not make such an attempt during our sample period. If the unobserved factors that lead to a decision to attempt to go public play an important role in our findings, we should expect very different estimates of δ across subsamples.

There are 29 firms (313 obs.) that successfully completed an IPO during our sample period, and 21 firms (233 obs.) that attempted, but failed to complete their IPO during our sample period. Thus the IPO-attempt sample totals 546 observations. We present the results for the no-transition attempt subsample (18,519 obs.) in Table 7, Panel A, columns I and II; and for the transition attempt subsample in columns III and IV. The point estimates for δ are very similar, although the statistical significance differs across subsamples due to

the difference in sample size. Overall, this evidence suggests that cross-sectional unobserved heterogeneity is unlikely to be driving our results.

TABLE 7

We next explore the possibility that time-variant unobserved heterogeneity could be driving our results. Specifically, private firms transitioning to public status may change in unobservable ways during the transition years, and this may be driving the differences in external financing sensitivity we find. To address this issue we extend Bernstein's (2015) IV approach to our setting. Bernstein (2015) instruments firms' trading status using the 2-month Nasdaq return firms face upon their IPO filling for a sample of firms that attempted an IPO — some firms completed the IPO successfully and others withdrew. Intuitively, firms that face a lower Nasdaq return upon filing for an IPO are more likely to remain private for exogenous reasons.

A difference between Bernstein's (2015) setting and ours is that he studies differences in levels (of innovation) between public and private firms — i.e., equivalent to studying β in equation (1). Our key coefficient of interest is δ — the interaction of the time-varying NCD shocks and trading status. In our setting, we need to instrument both the trading status, and its interaction with the NCD shock, which are time-variant. As the 2-month Nasdaq return upon IPO filing is time-invariant for each firm, this instrument drops out in our main specification containing firm-fixed effects. Thus, to instrument both *Private* and *Private*(NCD approval)* we use as instruments the interaction of Nasdaq returns with *NCD approval* and also the interaction between Nasdaq returns and time-varying firm characteristics (*log(Products per year PMA), log(Products per year 510K) and Products per employee*).[25] Interacting exogenous instruments with other covariates to generate further instruments has been used in several other settings (see, e.g., Angrist and Pischke, 2009). The interactions of 2-month Nasdaq return with time-varying variables likely satisfy

[25] Bernstein (2015) uses the Nasdaq return (on its own –not interacted) as an instrument as he collapses his data into a cross-section. We cannot do that as we study responses to time-varying investment opportunities.

the exclusion restriction, as the 2-month Nasdaq returns are unlikely to have a direct effect on yearly financing once controlling for year fixed-effects — the two-month window just affects the likelihood of going public.

We present the results of the second-stage regression in Table 7, Panel A, Columns V and VI, and those of the first stage in Table 7, Panel B. Following Bernstein (2015), we only use the transition-attempt subsample for this analysis, as the IV strategy is feasible only for this subsample. The results for the first-stage regression show that the instruments are strong, with F-tests values of 14 for the *Private* status and of 35.7 for the interaction *Private*(NCD approval)*. To illustrate the intuition of the first stage, consider this example. For the *Private* status first stage, one of the strongest instruments is the interaction between Nasdaq returns and *Log(Products per year PMA)*, which has a positive coefficient. This implies that while firms that experience a higher Nasdaq return during their IPO roadshow have a higher probability of becoming public (lower probability of staying private), this effect is moderated if a firm is producing more PMA products. Intuitively, firms introducing more PMA products need more funds and are more likely to go public regardless of the Nasdaq fluctuation — i.e., firms introducing more PMA products are less sensitive to Nasdaq fluctuations when it comes to deciding whether to complete an IPO.

The IV second-stage results show even sharper differences between the external financing sensitivities of public and private firms. Thus, to the extent that the direction of the estimates is informative, our results suggest that time-variant firm heterogeneity is unlikely to be biasing upwards the differences in external financing we find in the main analyses of the paper. That is, the difference in external financing sensitivity we document in our main analyses is likely a lower bound of the true difference that can be attributed to the trading status itself.

5.3. Which Securities Give the Financing Advantage to Publicly Traded Firms?

In this section we ask through which securities the financing advantage is occurring. We estimate a multinomial logit of security issuance using *NCD approval* as the main explanatory variable. We estimate

separate regressions for privately held and publicly traded companies, as their financing alternatives are different. For both estimations, the default option is "no external financing." For this analysis, we classify a firm attempting an IPO as a privately held company, since the decision of attempting an IPO is taken before the company changes its listing status.

The estimation results are shown in Table 8. Panel A shows the results for privately held companies and Panel B shows the results for publicly traded firms. For publicly traded firms we group fixed-income offerings and bank loans into a single category, "debt," as otherwise the dependent variable would be sparse, as there are only ten fixed-income transactions.

The results show that private companies have a slight increase in venture capital after an NCD approval. However, the estimated marginal effect is small. Publicly traded firms, on the other hand, have a sharp increase in private investments in public equity (PIPEs) that is economically large: the probability that a firm raises funds through a PIPE transaction in a given year increases by 22%, from 17.1% to 20.9%. Overall, the results indicate that PIPEs — which represent 64% of the transactions for public companies — are driving the result that public firms react more to better investment opportunities than private firms.

TABLE 8

One question that arises is why we do not observe more private firms obtaining venture capital, growth capital, or going public. We analyze four reasons: stock liquidity, stock informativeness, the existence of a winner-take-all effect due to the financing advantage of publicly traded firms, and the strength of competition that firms face. We analyze these reasons in more detail in the Section 6.

5.4. Acquisition Activity

Our results show that privately held firms raise less funds than similar publicly traded firms when facing improved investment opportunities. One possible explanation for this finding is that private firms raise fewer funds simply because they are more likely to be acquired after NCD approvals in their product

categories. We analyze this possibility by estimating multinomial logit regressions for private and public firms, where the default option is that a firm is not involved in acquisition activity, and the other alternatives are that a firm is acquired or that it acquires another firm. The results are shown in the Internet Appendix, Table IA.3. They show that neither private nor public firms are significantly more likely to be acquired after NCD approvals. Our results thus do not support the proposition that private firms are acquired after NCD approvals as a substitute for raising external capital.

The fact that NCD shocks have an important impact on financing — and product introductions, as we show below — but not on acquisitions is likely due to the focused nature of the firms in our sample. As described in Section 2, firms in our sample are small and operate in a single product category. Given their focused nature, these firms are less likely to engage in acquisitions. Also, more diversified firms (not in our sample) likely benefit from NCD approvals even without the need to acquire small focused firms.

6. Mechanisms

6.1. Stock Liquidity

Why does the higher external financing sensitivity to investment opportunities that we find for publicly traded firms operate through the private equity channel? For PIPE investments, practitioners tend to highlight the role of liquidity. PIPE investments can be exited as soon as the securities are registered. Thus, while PIPEs are not initially sold in the public market, the existence of publicly traded equity provides investors with better exit liquidity, making this form of private investment more attractive than less liquid investments in private firms.

To assess whether liquidity is indeed an important factor, we examine whether the differential external financing sensitivity of public versus private firms is higher when the public firms' stock is more liquid (above-median liquidity) than when it is less liquid (below-median liquidity). We compute stock (i)liquidity using three measures: *Amihud*'s (2002), *Zeros* (see Lesmond et al. 1999), and *Bid ask spreads*. We restrict

the public-firm sample to those firm-year observations for which we could observe at least 30 trading days. We present the results in Table 9. To preserve space, hereafter we only present the results for *log(Ext. fin. amount)*. The results for *Ext. fin. transaction* yield very similar results.

TABLE 9

The estimates from columns I and II show that the differential external financing sensitivity of publicly traded firms is substantially larger for public firms whose stock has higher liquidity. To further substantiate this claim we present the results from an analysis that pools liquid and illiquid public firms with private firms. We extend our triple difference methodology to allow for another category: Low liquidity public firms. In this analysis, the default category is public liquid firms, and the alternative categories are illiquid public firms and private firms. To account for this, we include the dummy *Low liquidity* and its interaction with *NCD approval*s in our main specification. We present the coefficients related to *NCD approvals* for the pooled sample in column III. For all liquidity measures the results clearly show that public liquid firms not only react to NCD approvals more than private firms, but also more than illiquid public firms. All interaction coefficients are statistically significant at the 1% level.

To shed more light on the liquidity interpretation, we look for the description of some of the PIPE transactions in which firms affected by an NCD approval raised funds. This information is shown in the Internet Appendix, Section A. The descriptions of the deals tend to highlight the availability of an "exit option" for investors. Securities issued in these transactions frequently contain explicit conversion rights that allow investors to convert into public equity at a later date, thus providing future liquidity to investors. Overall, our results are consistent with stock liquidity being an important factor in explaining the higher external financing sensitivity of public firms relative to private firms in response to the NCD shocks.

6.2. Stock Market Feedback Effects

Stock market feedback effects may also play a role in explaining the higher external financing sensitivity of public firms. Intuitively, changes in a public firm's stock price can provide both managers and investors with information about the value of an investment opportunity, allowing firms to raise more funds and at a lower cost than when such signals are weak or unavailable. Consistent with the notion that market feedback effects have an important role on corporate decisions, Chen et al. (2007) find that the amount of private information in stock price movements is positively correlated with the sensitivity of corporate investments to stock prices. Thus, we should expect a higher differential external financing sensitivity to investment opportunities between public and private firms when stock prices are more informative.

To explore this possibility, we study whether public firms with price informativeness above the median have a higher differential external financing sensitivity, relative to private firms, than public firms with price informativeness below the median. Our measure of stock price informativeness is stock price nonsynchronicity (Roll 1988; Chen et al. 2007), which captures the extent of a stock's unique information (i.e., not predicted by its industry or the market). In this analysis, the key explanatory variable is the stock price responsiveness to investment opportunity shocks, as firms may benefit differently from a given investment opportunity. Intuitively, a firm has stronger incentives to invest due to the market feedback channel both when its stock price reaction is positive and large, and when the amount of information from this stock price reaction is high.

We use a 180 day event window around the approvals to compute the stock price reaction to NCDs (Table 1, Panel C suggests that this window is appropriate). We call this variable "*Stock price reaction to NCD*." If a public firm experiences a NCD during a year, this variable takes the value of the cumulative stock return reaction to the shock; if not, it takes a value of 0. For private firms, the market can still learn something about the value of the investment opportunity from the stock price reaction of public firms in

their product category. Thus, for private firms the variable *Stock price reaction to NCD* is the average return of public firms in the same product category-year.

We present the results in Table 10. We find that public firms with more unique information in their stock (price informativeness above the median) have a higher external financing sensitivity to their stock price reaction to NCD shocks. This is consistent with stock market feedback effects playing a role in the financing advantage of public firms that we document.

In line with our analysis in Table 9, we also present the results from an analysis that pools public firms (with high and low stock price informativeness) and private firms. We extend our triple-difference methodology to allow for another category: public firms with low stock price informativeness. In this analysis, the default category is public firms with highly informative stock (informativeness above the median), and the alternative categories are public firms with below the median stock price informativeness and private firms. We include the dummy *Low info* and its interaction with NCD in our main specification. We present the coefficients related to *NCD approvals* in column III. The results clearly show that public firms with highly informative stock not only react to their stock price movements more than private firms, but also more than public firms with low unique informational content in their stock.[26]

TABLE 10

6.3. Product Market Competition

We now explore how our main findings depend on product market features. We first examine whether NCD approvals have an effect on product introductions, as the financing results would imply. Next, we

[26] These results are not driven by stock liquidity. In our sample, stock price informativeness negatively correlates with two of our measure of stock liquidity (*Amihud* and *Zeros*). We do not include other measures of stock price informativeness, such as PIN, as other papers have shown that the PIN is priced in the cross section because it apparently captures liquidity, and not information asymmetry (see Duarte and Young 2009).

examine how the type of products introduced by firms and product market competition relate to the financing advantage of publicly traded firms.

6.3.1. Product Introductions

In principle, companies should use the additional funds they obtain to take advantage of the improved investment opportunities coming from NCD approvals (i.e., they should invest more). Unfortunately, we do not have time-series data on private firms' R&D or capital expenditures to directly test this proposition. However, we have data on firms' FDA-approved product introductions/modifications, for both public and private firms. Therefore, we study whether product introductions (PMA and 510k), which are a long-run consequence of investment, are differentially affected for privately held and publicly traded firms.

We examine product introductions in a multivariate setting. We run regressions where the dependent variable is the number of products introduced by firms from year "t" to "t+x," where x={1, 2, 3, 4}. We examine product introductions for up to four years going forward, since product development and FDA approvals take time. The main explanatory variables are the dummy *Private*, the variable *NCD approval*, and the interaction term between these variables. As the number of products introduced between "t" and "t+x" is a count variable with overdispersion (i.e., the variance is higher than the mean), we estimate negative binomial regressions.

The results are shown in Table 11, Panel A. The economic effects are shown in the bottom row. The results indicate that firms affected by NCD approvals — both public and private — tend to introduce more products, although the effect is statistically significant only for publicly traded firms. The results also show that the differences in product introductions between private and public firms widens after NCD approvals, and it is significant. Overall, the more numerous product introductions that publicly traded firms display after NCD approvals are consistent with public firms having a financing advantage, as these firms have better access to external funds when investment opportunities improve.

TABLE 11

In Panels B and C we present results where we decompose product introductions into products introduced through the 510k approval process and products introduced through the PMA process. The evidence shows that there is an important advantage for public firms when it comes to modifications of existing products (510k process): While Public firms modify products in response to NCD approvals, private firms do not react at all. Regarding PMA product introductions, both public and private firms seem to react to NCD approvals, although the results are statistically significant only for publicly traded firms. We also present results examining patent introductions in the Internet Appendix (Table IA.4). The results are consistent with those of PMA introductions: for longer-term investments, which can potentially lead to a patent, both public and private firms seem to respond to NCD approvals.

The 510k results are consistent with a winner-take-all interpretation. To the extent that the benefits from product modifications are realized in the near future, public firms offering securities that provide investors with better exit liquidity are likely to raise the necessary funds to modify products; while private firms, which can only offer securities with low exit liquidity, cannot. As a consequence, public firms exercise quickly the value of the investment opportunity regarding product modifications, leaving private firms with few positive opportunities. The PMA results are consistent with a less pronounced financing advantage through the PIPE channel for publicly traded firms, given these are riskier and longer-term investments. If the horizon of the payback to investors is longer, the exit liquidity provided by PIPEs is less likely to be relevant. This, in turn, leads to a more moderate relative advantage regarding more novel product introductions for public firms.

6.3.2. Product Type and Financing

We now explore further the relation between the type of products introduced by firms and the financing advantage of publicly traded firms. If it is indeed the case that for product modifications (i.e., products introduced through the 510k process) there is a winner-take-all effect benefiting public firms, then we

should expect that private 510k-introducers do not raise additional funds following an NCD approval, while public 510k-introducers do. Relatedly, the higher financing response to investment opportunities of public firms should be *relatively* less pronounced for firms introducing more novel products (i.e., products introduced through the PMA process).

To examine this possibility, we categorize firms as PMA and 510k past introducers, according to whether they have introduced a PMA product, or not, during their first three years in the sample. Intuitively, we want to capture what "type" of firms they are prior to the NCD shocks. As the number of PMA introductions is quite skewed, only a few public firms (148 obs.) and private firms (362 obs.) can be classified as PMA introducers. In Table 12, Panel A, we show results examining the external financing sensitivity to investment opportunities for these two groups of firms.

TABLE 12

When focusing on 510k introducers, we find that only publicly traded firms raise additional funds, and privately held firms do not (the sum of the coefficients of *NCD approval* and *Private*(NCD approval)* is close to 0 and insignificant). However, when looking at PMA introducers we find that both public and private firms increase their external financing after an NCD approval, but to a different extent: Public firms raise 30% more funds, while private firms increase their external financing by 10% (the sum of the coefficients of *NCD approval* and *Private*(NCD approval)* is 10% and is statistically significant at the 5% level). To corroborate that private firms only respond to NCD shocks if they are PMA introducers we estimate a triple-difference specification for private firms only, using the "type" of firm as third difference. We present this result in column III. We also find that privately held firms do not react to NCD shocks if they are 510k introducers, but they do if they are PMA introducers. Our results are consistent with a winner-take-all interpretation for product modifications, and a *relatively* smaller financing advantage for public

firms when it comes to more novel product introductions.[27] Overall, these findings are consistent with the product introduction results.

6.3.3. Product Type and Choice of Security

Our findings suggest that PIPE financing allow public firms to have higher external financing sensitivity to investment opportunities than private firms, as they provide a liquidity advantage to investors and there seems to be a winner-take-all effect. However, our findings have not yet shed light on when other financing alternatives, such as SEOs, can also play a role in the financing of publicly traded firms. We posit that in settings where long-term investments are more relevant, SEOs can play a more important role in the financing of investment opportunities of public firms. SEO transactions typically involve larger amounts (novel product introductions may require additional funding), and should not be at an important disadvantage relative to PIPE investments when the horizon of the investment opportunity is of a longer term. To explore whether this possibility, we extend our multinomial logit analysis for public firms (Table 8, Panel B) by differentiating NCD shocks that affect 510k and PMA introducers. We present these results in Table 12, Panel B.

The results indicate that SEOs increase following NCD approvals for PMA introducers, but not for 510k introducers.[28] The difference in coefficients for the SEO choice is statistically significant at the 1% level. This finding is important as it is consistent with SEOs being a useful alternative to raise funds for long-term investments, and thus highlights when SEOs maybe preferred.

[27] We do not intend to show that the *absolute* financing sensitivities are different according to firms' product types, as there are two conflicting effects: On the one hand the *relative* financing advantage of public firms versus private firms is larger when modifying products — the ratio of financing sensitivities for public vs private firms is 3 (=30%/10%) for PMA introducers but infinity (=16%/0%) for 510k introducers. But on the other hand, modifying products require less funding, so the *absolute* financing difference can be similar: 20%(=30%-10%) for PMA introducers and 16%(=16%-0%) for 510k introducers.

[28] By means of comparison, in Table 8, when pooling both types of firms together, the effect was statistically insignificant.

NCD approvals also have a slightly larger effect for PMA introducers than for 510K introducers among PIPE issuances, however the coefficients are not statistically different from each other. This lack of statistical difference is expected, given that for PIPEs the type of product introduced by firms involves two conflicting effects. On the one hand, (some) product modifications may not need external funding, and thus 510k introducers may raise less funds than PMA introducers following a NCD approval. But on the other hand, PIPEs can be more relevant when financing short-term investments.

6.3.4. Financing and Competitors' Strength

Our results indicate that publicly traded firms enjoy a financing advantage that makes them stronger competitors, especially when it comes to shorter-term investments. To shed more light on the interaction between financing and competitive strength we study whether the financing advantage of public firms is, in turn, affected by the strength of their rivals. We use the fraction of publicly traded firms operating in a product category as a measure of competitor strength: Public firms are strong competitors, since (as we show) they can react more strongly to investment opportunities by using external financing. We consider both multi- and single-segment public firms as competitors for this analysis.[29] We present the results splitting the sample according to the fraction of public firms competing in a product category in Panel C of Table 12.

We find that the financing advantage of single-segment public firms is smaller in product categories with a larger fraction of public firms. Thus, while being publicly traded provides a financing advantage, the magnitude of this advantage decreases with the strength of competitors. This result further highlights the importance of the role of ownership in firms' ability to capture the benefits of an investment opportunity.

[29] For this analysis we additionally hand-collect data on the trading status of multi-segment firms. When constructing the fraction of public firms in each product category-year we use weighted averages, where the weights used are the fraction of products introduced by each firm in a product category.

We also examine whether the difference in the financing advantage for firms operating in a product category with high vs low competition is statistically significant. Relative to Tables 9 and 10, where we cannot assign a measure of liquidity or price informativeness to private firms, here we can assign a measure of competitiveness to both public and private firms. Thus, we perform a quadruple-difference estimation. We present the results for the *NCD approval* coefficient and its interactions in column III. The results show that the coefficient of *High Competition x NCD approval* is negative and statistically significant, and that the coefficient of *High Competition x Private x NCD approval* is positive and statistically significant. This implies that (single-segment) public firms have a smaller financing advantage relative to private firms in a more competitive environment. Overall, our results are consistent with single-segment public firms having a larger financing advantage when competition is softer.

7. Alternative Explanations

7.1. Agency-based Explanations

Our main results show that publicly traded firms have a higher external financing sensitivity to investment opportunities than private firms. We interpret this result as evidence of a financing advantage, as public firms raise more funds following positive investment opportunity shocks and use them to introduce more products. Our interpretation is that the financing advantage dominates the potential (agency-based) short-term focus of managers of public firms that may lead them to under-invest in response to investment opportunities (see Sheen (2009) and Asker et al. (2015)).

An alternative agency-based interpretation for our findings is that managers of public firms have a tendency to *over*-invest, so the higher external financing sensitivity we observe may be due to public firms using additional funds in negative-NPV projects, on the margin. We examine this possibility using several tests. First, we split our sample of public firms using two common proxies for agency problems that may cause over-investment: Cash holdings and (low) institutional ownership. In the Internet Appendix, Table IA.5, we show that publicly traded firms with high cash holdings and low institutional ownership (i.e.,

more prone to agency problems) display similar differential external financing sensitivities relative to private firms than public firms with low cash holdings and high institutional ownership (there are no statistical significant differences across samples).[30] This evidence is inconsistent with agency-based over-investment tendencies driving our results.

Second, we collect data on the projected market sizes of each product category and show that product introduction rates increase with the potential market size of the product category. We also show that privately held firms tend to increase their product introductions by more than public firms, following an NCD approval, if they operate in a larger category (i.e., the coefficient of *Private*NCD approval*Category Size* is positive). We present these results in the Internet Appendix, Table IA.6, Panel A. Given that the profitability of a new product is expected to increase in the potential size of its market, these results are inconsistent with higher product introduction rates by public firms being an indication of over-investment.

Third, we show that public firms display positive CARs upon product introductions (Table IA.6, Panel B), indicating that introducing products is well received by the market. This evidence is inconsistent with public firms destroying value through product introductions. Collectively, our results indicate that the additional financing and product introductions displayed by public firms following NCD approvals are not explained by over-investment tendencies coming from agency problems.

7.2. NCD Approvals and Public-Firm Financial Policies

We interpret our findings on financing and product introductions as evidence that, due to a financing advantage, public firms are able to introduce more products and thus have a competitive advantage in the product market. However, there may be instances where public firms had invested in R&D before an NCD approval, but they decided to raise funds anyway because the NCD approval is a positive market signal.

[30] Our sample of public firms is restricted to those that have data available on cash holdings and institutional ownership.

Instead of being invested in more R&D, such funds could be used for other purposes, e.g., for dividends, advertising, or for retained cash.

We explore this possibility by examining the effect of NCD approvals on several financing policies of public firms: R&D expenses, Capex, advertising expenses, payout and retained cash. The results are presented in the Internet Appendix, Table IA.7. The results clearly show that while R&D does increase during the NCD years, there are no significant increases in the other possible uses of funds.

In addition, we explore whether R&D, or other firm policies, were underway prior to the NCD shock. We run fixed effects regressions using the same firm policies as dependent variables, and using years relative to NCD shocks as explanatory variables. We plot the coefficients of the regressions in Figure 2.

Figure 2 here

As the figure shows, R&D was not underway prior to NCD approvals; it increases during the NCD approval year and after, consistent with the notion that firms raise funds externally to invest. This result is also consistent with the product introduction results (Table 11). Other firm policies do not experience important changes around NCD approvals. These results support the interpretation that firms raise funds following an NCD approval to invest in R&D and in new product introductions.

8. Conclusions

We examine the financing decisions and subsequent product introductions of private and public firms in the medical device industry, after changes to their investment opportunities. We use Medicare national coverage decisions as shocks to firms' investment opportunities. We find that public companies increase their external financing and introduce more products than private companies in response to these national coverage approvals; and that the financing advantage stems from the private equity channel. Our results are robust to the inclusion of variables that control for firm size, technology and productivity, to different matching procedures, and to instrumenting firms' trading status to deal with selection.

We show *why* there is a financing advantage for public firms in the private equity markets. PIPEs provide better exit liquidity than investments in private firms. Also, market feedback effects coming from publicly traded firms' stock prices allow managers and investors to learn more about the investment opportunities available to public firms. This, in turn, allows public firms with higher price informativeness to raise more funds.

In addition, we show that the type of products introduced by firms shapes the financing advantage. We find that the financing advantage is more pronounced for firms modifying existing products, consistent with a winner-take-all effect: Firms enjoying better financing options capture the largest share of the investment opportunity. For longer-term investments, both private and public firms increase external financing, although public firms still raise more external capital in this case.

Overall, our evidence is consistent with the advantages of being publicly traded outweighing the costs in industries that are competitive, rapidly growing, somewhat opaque and in need of external financing. We document that public firms enjoy a financing advantage that helps them offset the issuance and potential agency costs typically associated with public ownership. Rapid access to external finance has important advantages that allow public firms with new investment prospects to quickly exploit these new opportunities.

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Figure 1

Distribution of Firm Entry

This figure shows the distribution of new founded firms for product-category-years with and without NCD approvals.

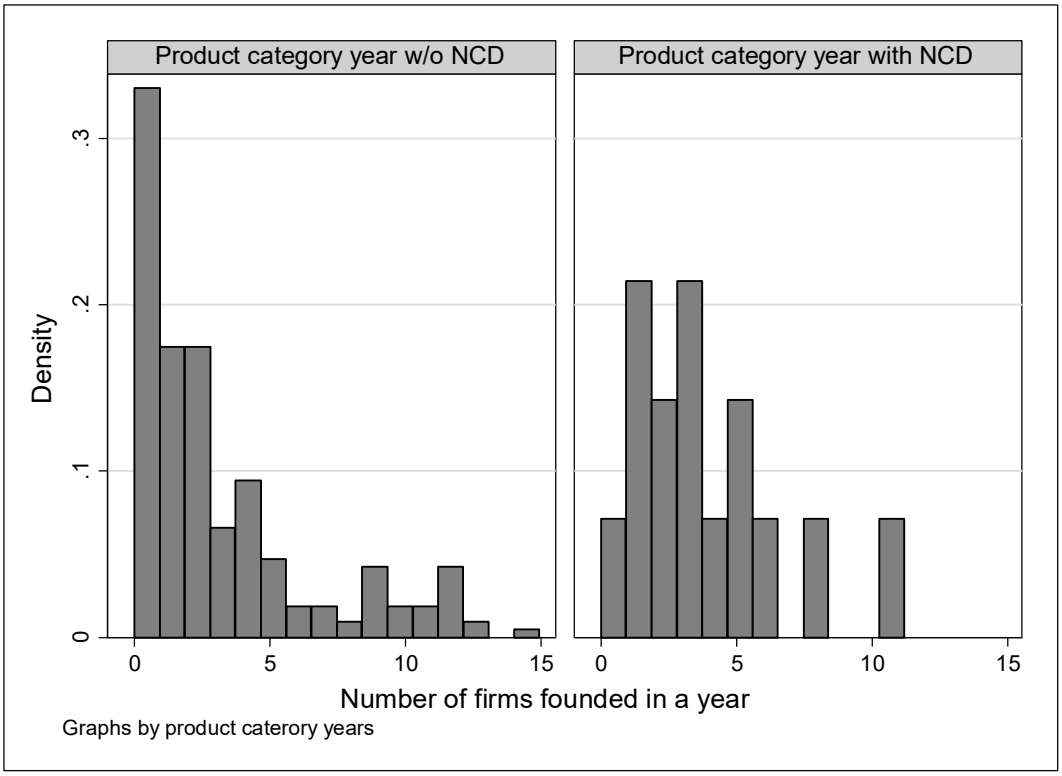

Figure 2

Publicly Traded Firms' Policies around NCDs

This figure plots the coefficients from fixed effects regressions where the explanatory variables are years relative to NCD shocks. The dependent variables are R&D, Capex, advertising expense, total payout and cash over assets. The sample is restricted to publicly traded firms.

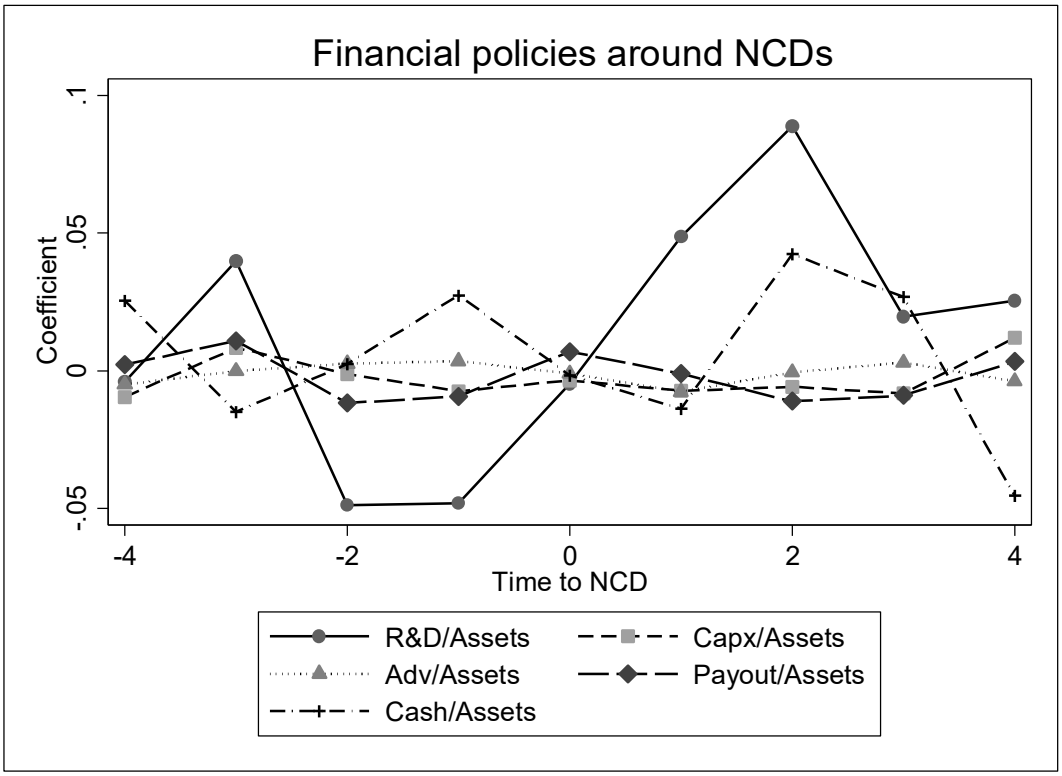

Table 1. National Coverage Decision (NCD) Approvals and Extensions for 1998-2010

Panel A summarizes the seventeen national coverage decision (NCD) approvals issued by Medicare during 1998-2010. Column I shows the FDA product category of each device. Column II shows the name of the device that obtained national coverage approval. Column III shows the year in the sample period in which the device was first approved — or the first year in the sample period the device was granted extended coverage if initial coverage was approved before 1998. Columns IV and V show the year in which some of the devices obtained extended coverage during the sample period. Column VI shows the year in which the device was initially approved, in case the initial approval was prior 1998. Panel B shows the product categories that did not receive an NCD approval during the sample period. Panel C shows the results of an event study of firms' returns, using NCD approvals/extensions by Medicare as events. The firms analyzed are publicly traded firms operating in product categories affected by an NCD approval. Excess stock returns are calculated over a single factor model with parameters estimated over a 200 day interval (-300, -100). Significant at: *10%, **5% and ***1%.

Panel A: NCD approvals by Medicare, 1998-2010

FDA Device Classification	Medical Device	First Appr. in Sample	First Exten. in Sample	Second Exten. in Sample	Initial Appr.	FDA Review Process
Anesthesiology (AN)	Continuous Positive Airway Pressure (CPAP) Therapy	2001	2008		1986	510K
Cardiovascular (CV)	Implantable Automatic Defibrillators	1999	2003	2004	1986	PMA
Cardiovascular (CV)	Artificial Hearts and Related Devices (VAD)	2003	2010		1993	PMA
Ear Nose & Throat (EN)	Speech Generating Devices	2001				PMA
Ear Nose & Throat (EN)	Cochlear Implantation	2004			1986	PMA
Gastroenterology/Urology (GU)	Sacral Nerve Stimulation For Urinary Incontinence	2001				PMA
Gastroenterology/Urology (GU)	Non-Implantable Pelvic Floor Electrical Stimulator	2001				510k
General Hospital (HO)	Infusion Pumps	2004			1984	PMA
Neurology (NE)	Vagus Nerve Stimulation (VNS)	1999				PMA
Neurology (NE)	Deep Brain Stimulation	2002				PMA
Neurology (NE)	Neuromuscular Electrical Stimulation (NMES)	2002				510K
Physical Medicine (PM)	Mobility Assistive Equipment (MAE)	2005	2007			510K

Panel B: Product categories without NCD approvals, 1998-2010

Clinical Chemistry (CH)
Dental (DE)
Hematology (HE)
Immunology (IM)
Microbiology (MI)
Obstetrics/Gynecology (OB)
Ophthalmic (OP)
Orthopedic (OR)
Pathology (PA)
Radiology (RA)
Surgery (SU)
Toxicology (TX)

Panel C: Cumulative abnormal returns around NCD events

Event Window	CAR
-90, +90	21.3%**
-60, +60	12.8%**
-10, +10	3.0%

Table 2. Summary Statistics

This table shows the summary statistics for our sample. *External financing amount* represents the yearly amount of external financing raised by the companies in our sample. If a company does not raise funds externally in a year, this variable takes a value of zero; if it does, it takes the transaction amount (in 2011 US dollars). *External financing transaction* takes a value of zero if a firm did not obtain external financing in a year, and one if it obtained external financing. The variable *Private* is a dummy variable which takes a value of zero if a company was publicly listed in a year, and one otherwise. *Products per year* is the number of FDA-approved new products and approved modifications to existing products granted to a firm in a year. *Products per year* (510 k) is the number of FDA-approved products to a firm in a year, which are substantially equivalent to other existing products. *Products per year* (PMA) is the number of FDA-approved products to a firm in a year, which underwent Premarket Approval (i.e., novel devices). The variable *Age* is the year of operations minus the founding year. *Sales* represent the 2011 sales of a company in millions of dollars; *Sales/Employee* represents the 2011 ratio of sales per employee of a firm. *Products per year/Employee* is the ratio of products introduced/modified by a firm in a given year divided by its 2011 employees. *Patent issuer* takes a value of one if a firm has ever been granted a patent during the sample period, and zero otherwise. *Patents granted per year* indicates the average number of patents granted in a year to firms in the sample. The variable *NCD approval* takes a value of one if a firm operates in product category that received an NCD approval, for the NCD year itself and the next two years, and zero otherwise.

Variable	Mean	Pctile 50	sd	N
Ext. fin. amount (US$ million)	1.03	0.0	7.0	19065
Ext. fin. transaction	0.06	0.0	0.2	19065
Private	0.94	1.0	0.2	19065
Products per year	0.61	0.0	3.5	19065
Products per year (510 k)	0.28	0.0	0.8	19065
Products per year (PMA)	0.33	0.0	3.4	19065
Age	16.57	12.0	17.5	19065
Sales (US$ million)	13.28	2.7	30.6	19065
Patent issuer	0.39	0.0	0.5	19065
Patents granted per year	0.22	0.00	0.97	19065
Products per year/Employee	0.03	0.0	0.14	19065
Sales/Employee (US$ million)	0.16	0.1	0.21	19065
NCD approval	0.25	0.0	0.6	19065

Table 3. External Financing Transactions

Panels A and B show the transaction types and average dollar value per transactions for subsamples of private and publicly traded companies. Panel C shows time (in days) since announcement until closing for all equity transactions and time from closing until registration for PIPE deals. Panel D shows differences in shares outstanding and short interest around actual PIPE dates and placebo dates (one year prior and one year after the actual PIPE date). Column I shows the differences between six months after and six month prior to the actual PIPE issuance date. Column II repeats the analysis for the placebo PIPE issuance dates. Column III shows difference-in-difference estimates in shares outstanding and short interest. Significant at: *10%, **5% and ***1%.

Panel A: Transaction Types and Values for Private firms (18,006 firm-year obs; 1,728 firms)

Transaction Type	Number of Transactions (#)	% of Deals	Average Transaction Value (US$ Million)
Growth Capital/ Private Equity	249	28%	12.6
IPO	29	3%	60
Venture Capital	590	66%	12.8
Bank Loan	23	3%	36.3
Total	891		

Panel B: Transaction Types and Values for Public firms (1,059 firm-year obs; 101 firms)

Transaction Type	Number of Transactions (#)	% of Deals	Average Transaction Value (US$ Million)
Fixed Income Offering	10	4%	52.5
Seasoned Equity Offering	56	20%	47.2
Private Equity (PIPE)	176	64%	14.2
Bank Loan	34	12%	22.2
Total	276		

Panel C: Time Since Annoucement — Equity Transactions

Transaction Type	Mean (Median) Days from Annoucement to Closing	Mean (Median) Days from Closing to Registration
Private		
Growth Capital/ Private Equity	35 (0)	-
IPO	124 (91)	-
Venture Capital	21 (0)	-
Public		
Seasoned Equity Offering	129 (28)	-
Private Equity (PIPE)	24 (2)	126 (29)

Panel D: Diff-in-Diff — Shares Outstanding and Short Interest

	First Diff: Post-Pre PIPE Issuance Dates	First Diff: Post-Pre Placebo Dates	Diff-in-Diff
Shares Outstanding	12.4%***	7.9%***	4.5%**
Short Interest	0.34%***	0.08%	0.26%**

Table 4. Private and Public External Financing Sensitivity to Investment Opportunities

This table presents results from estimations of equation (1). Panel A presents regressions examining external financing transaction amounts and Panel B presents regressions examining the likelihood of an external financing transaction. Columns I and II present the results using linear regressions and column III presents the results of non-lineal estimations (Tobit in Panel A and Probit in Panel B). The controls included are the logarithm of products per year (510k), the logarithm of products per year (PMA), products per year per employee, age, logarithm of sales and sales per employee. Panel C shows the economic effect of NCD approvals for private and public firms from three angles: First, the amount of external funds raised; second, the probability of raising external funds in a year; and third, the amount raised conditional on observing an external financing transaction in a year. Significant at: *10%, **5% and ***1%. Standard errors are adjusted for heteroscedasticity and clusters at the product category level.

Panel A: Ext. fin. amount			Tobit
Variable	**Log(Ext. fin. amount)**	**Log(Ext. fin. amount)**	**Log(Ext. fin. amount)**
Private	-0.5034**	-0.5013**	-4.3080***
	(0.1787)	(0.1785)	(0.3276)
NCD approval	0.1773***	0.2087***	1.6626***
	(0.0226)	(0.0234)	(0.2880)
Private*(NCD approval)	-0.1839***	-0.1942***	-0.9206***
	(0.0242)	(0.0236)	(0.2830)
Controls	Yes	Yes	Yes
Controls*(NCD approval)	No	Yes	Yes
Firm Fixed Effects	Yes	Yes	No
Year Fixed Effects	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes
R-squared (within)	0.0111	0.0116	0.077
N	19065	19065	19065
Panel B: Ext. fin. transaction			Probit
Variable	**Ext. fin. transaction**	**Ext. fin. transaction**	**Ext. fin. transaction**
Private	-0.1044	-0.1049	-1.0066***
	(0.0744)	(0.0746)	(0.0583)
NCD approval	0.0571***	0.0604***	0.4506***
	(0.0089)	(0.0132)	(0.0689)
Private*(NCD approval)	-0.0611***	-0.0602***	-0.2520***
	(0.0086)	(0.0105)	(0.0615)
Controls	Yes	Yes	Yes
Controls*(NCD approval)	No	Yes	Yes
Firm Fixed Effects	Yes	Yes	No
Year Fixed Effects	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes
R-squared (within)	0.0058	0.0061	0.106
N	19065	19065	19065

Panel C: Economic Effect of a NCD approval on External Financing

	Private	Public	Difference
External funds increase (unconditionally) by:	-0.7%	17.7%***	18.4%***
Probability of external financing increases by:	-0.4%	5.7%***	6.1%***
Conditional on having an external financing transaction, external funds increase by:	3.7%***	8.3%***	4.6%***

Table 5. Univariate Analysis and Matched Samples

Panel A shows the differences in variable means for publicly traded and private firms for the main sample. Panels B-D compare three subsamples of matched observations, using propensity score matching (described in the text). Significant at: *10%, **5% and ***1%.

Panel A: Full Sample

Variable	Public (i=101; N=1,059)	Private (i=1,728; N=18,006)	Difference (Public-Private)
Products per year (510 k)	0.37	0.28	0.09***
Products per year (PMA)	3.7	0.1	3.6***
Age	17.2	16.5	0.7
Sales (US$ million)	38.8	11.8	27***
Products per year/Employee	0.34	0.29	0.05
Sales/Employee (US$ million)	0.21	0.16	0.05***

Panel B: Matching on initial observation

Variable	Public (i=46; N=598)	Private (i=46; N=598)	Difference (Public-Private)
Products per year (510 k)	0.28	0.24	0.04
Products per year (PMA)	0.3	0.0	0.3*
Age	12.4	10.5	1.9
Sales (US$ million)	14.7	16.3	-1.6
Products per year/Employee	0.04	0.02	0.02
Sales/Employee (US$ million)	0.20	0.18	0.02

Panel C: Matching within a product category

Variable	Public (i=59; N=568)	Private (i=154; N=568)	Difference (Public-Private)
Products per year (510 k)	0.25	0.25	0.00
Products per year (PMA)	0.36	0.13	0.23**
Age	16.5	16.8	-0.3
Sales (US$ million)	16.3	13.4	2.9*
Products per year/Employee	0.019	0.013	0.006
Sales/Employee (US$ million)	0.17	0.15	0.02

Panel D: Matching obs. (max. accuracy)

Variable	Public (i=98; N=954)	Private (i=411; N=954)	Difference (Public-Private)
Products per year (510 k)	0.34	0.38	-0.04
Products per year (PMA)	0.60	0.54	0.06
Age	17.1	19.8	-2.7***
Sales (US$ million)	30.4	30.7	-0.3
Products per year/Employee	0.022	0.017	0.004
Sales/Employee (US$ million)	0.20	0.24	-0.04***

Table 6. Matched Sample Regression Results

Panels A and B present the results from the main regression analysis using different subsamples. Column I presents results using the sample matched on initial observations (differences shown in Table 5 Panel B), column II presents results using the sample matched within product categories (differences shown in Table 5 Panel C), column III presents results using the sample matched at the observation level (differences shown in Table 5 Panel D). Column IV presents results using all public firms and the subset of privately held firm-year observations that had received external equity financing from financial institutions. Controls are those included in Table 4 and the dummy *Private*. Standard errors are adjusted for heteroscedasticity and clusters at the product category level. Significant at: *10%, **5% and ***1%.

Panel A: Ext. fin. amount	Sample matched on initial observation	Sample matched within a product category	Sample matched at the obs. level	Public firms and financially backed private firms
Variable	**Log(Ext. fin. amount)**	**Log(Ext. fin. amount)**	**Log(Ext. fin. amount)**	**Log(Ext. fin. amount)**
NCD approval	0.1708***	0.1281***	0.1414***	0.1649***
	(0.0303)	(0.0394)	(0.0275)	(0.0234)
Private*(NCD approval)	-0.2821***	-0.1828***	-0.1606***	-0.2005***
	(0.0717)	(0.0509)	(0.0474)	(0.0216)
Controls	Yes	Yes	Yes	Yes
Controls*(NCD approval)	No	No	No	No
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes	Yes
R-squared (within)	0.0504	0.0410	0.0326	0.0129
N	1196	1136	1908	4832
Panel B: Ext. fin. transaction				
Variable	**Ext. fin. transaction**	**Ext. fin. transaction**	**Ext. fin. transaction**	**Ext. fin. transaction**
NCD approval	0.0452***	0.0285	0.0384***	0.0518***
	(0.0144)	(0.0221)	(0.0100)	(0.0091)
Private*(NCD approval)	-0.0929***	-0.0621**	-0.0658***	-0.0690***
	(0.0230)	(0.0263)	(0.0121)	(0.0069)
Controls	Yes	Yes	Yes	Yes
Controls*(NCD approval)	No	No	No	No
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes	Yes
R-squared (within)	0.0455	0.0474	0.0320	0.0087
N	1196	1136	1908	4832

Table 7. Transition Samples and IV Strategy

This table shows results for subsamples of firms according to whether they attempted and IPO, or not, during the sample period; and results for instrumental variable regressions using the subsample of firms that attempted an IPO during the sample period. Panel A, columns I and II show results from OLS estimations for firms that did not attempt an IPO during the sample periods. Columns III and IV show results from OLS estimations for firms that attempted an IPO during the sample period. There were 29 successful attempts (313 obs.) and 21 unsuccessful attempts (233 obs.). Columns V and VI shows results for the second stage of two stage least square regressions using the subsample of firms that attempted an IPO. The endogenous regressors are the dummy *Private* and its interaction with *NCD approval*. The instruments are the interaction of firms' time-varying characteristics and *NCD approval* with the 2-month Nasdaq return firms face when filing for an IPO. The first stage estimates are shown in Panel B. Controls are those included in Table 4. Standard errors are adjusted for heteroscedasticity and clusters at the product category level. Significant at: *10%, **5% and ***1%.

Panel A: No Transition attempt Sample, Transition Attempt Sample and 2SLS

	No transition attempt sample		Transition attempt sample: Firms with completed and canceled IPOs			
	OLS		OLS		2SLS-IV	
Variable	**Log(Ext. fin. amount)**	**Ext. fin. transaction**	**Log(Ext. fin. amount)**	**Ext. fin. transaction**	**Log(Ext. fin. amount)**	**Ext. fin. transaction**
Private			-0.0036	0.0202	-1.9329	-0.6458
			(0.1795)	(0.0826)	(1.1913)	(0.3944)
NCD approval	0.1946***	0.0681***	0.1452	0.0577	0.8530**	0.2395**
	(0.0222)	(0.0103)	(0.1090)	(0.0484)	(0.4065)	(0.1208)
Private*(NCD approval)	-0.2020***	-0.0722***	-0.1811	-0.0717	-1.3665**	-0.3685*
	(0.0260)	(0.0125)	(0.1850)	(0.4168)	(0.6717)	(0.2081)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes	Yes	Yes	Yes
R-squared (within)	0.0063	0.0045	0.0325	0.0259	0.0109	0.0111
N	18519	18519	546	546	546	546
F-statistic (instruments)					**Private: F=14**	
					Private*(NCD approval): F=35.7	

Panel B: IV, First Stage

	FIRST STAGE	
Variable	**Private**	**Private*(NCD approval)**
NCD approval	0.0256	0.5698***
	(0.0289)	(0.0262)
Log(products per year 510k)	-0.0714**	-0.0708
	(0.0274)	(0.0478)
Log(products per year PMA)	-0.0436	0.0208
	(0.0372)	(0.0127)
Products per employee	0.1729	-0.0215
	(0.1158)	(0.0835)
Nasdaq returns*(NCD approval)	0.2508**	-1.1386***
	(0.1149)	(0.1425)
Nasdaq returns*	-0.7901	-1.2892*
Log(products per year 510k)	(0.8756)	(0.7336)
Nasdaq returns*	2.0798***	0.0548
Log(products per year PMA)	(0.4300)	(0.1545)
Nasdaq returns*	0.4164	7.7337**
Products per employee	(4.0397)	(3.0097)
Controls	Yes	Yes
Firm Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Product Category Cluster	Yes	Yes
R-squared (within)	0.4076	0.5580
F-statistic (instruments)	14	35.7
N	546	546

Table 8. Multinomial Logit Estimation of Transaction Types

This table presents multinomial logit regressions examining different types of financing decisions for both privately held and publicly listed companies. Panel A presents a multinomial logit of financing decisions for privately held companies, where the default option is not obtaining external financing. Panel B presents a multinomial logit of financing decisions for publicly listed companies, where the default option is not obtaining external financing. Controls are those included in Table 4. We do not consider transactions of less than two million dollars in this analysis, as these mostly represent follow-up financing rounds from earlier transactions. Standard errors are adjusted for heteroscedasticity and clusters at the product category level. Significant at: *10%, **5% and ***1%. The changes in probabilities following an NCD approval are shown at the bottom of each panel.

Panel A: Private firms

	Default option: No external financing			
Variable	**Bank Loan**	**Venture capital**	**Growth capital**	**IPO**
NCD approval	0.2613	0.0403	-0.0739	0.1814
	(0.3037)	(0.1458)	(0.2066)	(0.1986)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
N		18035		
Unconditional probability	0.1%	3.3%	1.4%	0.2%
Marginal effect (NCD approval)	0.00%	0.02%	-0.04%	0.00%
Δ Probability following NCD approval	0.1%	0.7%	-3.1%	0.2%

Panel B: Public Firms

	Default option: No external financing		
Variable	**Debt**	**PIPE**	**SEO**
NCD approval	-0.1692	0.3521***	0.0718
	(0.2622)	(0.0853)	(0.0986)
Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
N		1030	
Unconditional probability	4.3%	17.1%	5.4%
Marginal effect (NCD approval)	-0.01%	3.8%	0.01%
Δ Probability following NCD approval	-0.2%	22.1%	0.2%

Table 9. Stock Liquidity and Financing

Columns I and II present results from estimating equation (1) for all private firms and subsamples of publicly traded firms, according to their stock liquidity (above and below the median) using three measures: *Amihud, Zeroes*, and *Bid ask spreads*. Column III presents results using the pooled sample and extending equation (1) by including the dummy *Low liquidity*, which takes a value of 1 for low liquidity public firms, and 0 otherwise, and its interaction with NCD approval. Controls are those included in Table 4. Standard errors are adjusted for heteroscedasticity and clusters at the product category level. Significant at: *10%, **5% and ***1%.

		Liquidity above the median	Liquidity below the median	Pooled sample
Liquidity measure	**Variable**	**Log(Ext. fin. amount)**	**Log(Ext. fin. amount)**	**Log(Ext. fin. amount)**
Amihud	**NCD approval**	0.1779***	0.0957**	0.2017***
		(0.0618)	(0.0375)	(0.0657)
	Private*(NCD approval)	-0.1829**	-0.0998**	-0.2076***
		(0.0646)	(0.0369)	(0.0681)
	Low liquidity*(NCD approval)			-0.1845**
				(0.0859)
	R-squared (within)	0.0105	0.0068	0.0160
	N	18362	18362	18729
Zeroes	**NCD approval**	0.1982***	0.0597	0.1746***
		(0.0228)	(0.0431)	(0.0299)
	Private*(NCD approval)	-0.2016***	-0.0649	-0.1797***
		(0.0243)	(0.0453)	(0.0297)
	Low liquidity*(NCD approval)			-0.1253**
				(0.0503)
	R-squared (within)	0.0143	0.0025	0.0171
	N	18380	18367	18754
Bid ask spread	**NCD approval**	0.2606***	0.1048*	0.3089***
		(0.0688)	(0.0531)	(0.0778)
	Private*(NCD approval)	-0.2649***	-0.1087**	-0.3154***
		(0.0705)	(0.0512)	(0.0809)
	Low liquidity*(NCD approval)			-0.2581**
				(0.1071)
	R-squared (within)	0.0069	0.0211	0.0199
	N	18382	18304	18680
	Controls	Yes	Yes	Yes
	Firm Fixed Effects	Yes	Yes	Yes
	Year Fixed Effects	Yes	Yes	Yes
	Product Category Cluster	Yes	Yes	Yes

Table 10. Stock Informativeness and Financing

Columns I and II present results from estimating equation (1) for all private firms and subsamples of publicly traded firms, according to their stock price informativeness (above and below the median), measured by stock price nonsynchrronicity (Roll 1988; Chen, Goldstein and Jiang 2007). Column III presents results using the pooled sample and extending equation (1) by including the dummy *Low info*, which takes a value of 1 for public firms with low private informational content, and 0 otherwise, and its interaction with NCD approval. Controls are those included in Table 4. Standard errors are adjusted for heteroscedasticity and clusters at the product category level. Significant at: *10%, **5% and ***1%.

	Price informativeness above the median	**Price informativeness below the median**	**Pooled sample**
Variable	**Log(Ext. fin. amount)**	**Log(Ext. fin. amount)**	**Log(Ext. fin. amount)**
Stock price reaction to NCD	0.1452***	-0.1250	0.1411***
	(0.0316)	(0.1263)	(0.0317)
Private*(Stock price reaction to NCD)	-0.1488***	0.1240	-0.1418***
	(0.0329)	(0.1285)	(0.0364)
Low info*(Stock price reaction to NCD)			-0.2230**
			(0.0933)
R-squared (within)	0.0072	0.0108	0.0141
N	18367	18367	18728
Controls	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes

Table 11. Product Introduction Regressions

Panels A-C present results from negative binomial regressions examining cumulative product introductions from year t to t+x, where x={1,2,3,4}. The controls included are the dummy *Private*, age, logarithm of sales and sales per employee. Standard errors are adjusted for heteroscedasticity and clusters at the product category level. Marginal effects of NCD approvals on product introductions of private and public firms, as well as their differences, are shown at the bottom of the panels. Panel A presents results considering all types of product introductions; Panel B considers 510k product introductions; and Panel C considers PMA product introductions.

Panel A: All products

Variable	Prod. intro. (t-t+1)	Prod. intro. (t-t+2)	Prod. intro. (t-t+3)	Prod. intro. (t-t+4)
NCD approval	0.3296***	0.3212***	0.3689***	0.4098***
	(0.1075)	(0.1088)	(0.1103)	(0.1085)
Private*(NCD approval)	-0.3785**	-0.3410*	-0.3471*	-0.3527**
	(0.1807)	(0.1903)	(0.1924)	(0.1776)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes	Yes
N	17262	15480	13727	12007
NCD approval marginal effect for private firms	0.00	0.02	0.04	0.11
NCD approval marginal effect for public firms	0.17***	0.35***	0.57***	0.81***
NCD differential effect (public vs. private)	0.17***	0.33**	0.53**	0.70**

Panel B: Product Modifications (510k)

Variable	510k intro. (t-t+1)	510k intro. (t-t+2)	510k intro. (t-t+3)	510k intro. (t-t+4)
NCD approval	0.1482**	0.1566**	0.1624*	0.1707*
	(0.0703)	(0.0729)	(0.0829)	(0.0931)
Private*(NCD approval)	-0.2756***	-0.2756**	-0.2633**	-0.2448*
	(0.1066)	(0.1139)	(0.1278)	(0.1373)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes	Yes
N	17262	15480	13727	12007
NCD approval marginal effect for private firms	-0.03	-0.06	-0.07	-0.07
NCD approval marginal effect for public firms	0.04***	0.08***	0.20***	0.18**
NCD differential effect (public vs. private)	0.07***	0.14**	0.27**	0.25*

Panel C: Product Modifications - PMA

Variable	PMA intro. (t-t+1)	PMA intro. (t-t+2)	PMA intro. (t-t+3)	PMA intro. (t-t+4)
NCD approval	0.4487**	0.3940**	0.4443***	0.5032***
	(0.1758)	(0.1896)	(0.1665)	(0.1530)
Private*(NCD approval)	-0.4221	-0.2977	-0.3384	-0.3495
	(0.3366)	(0.3821)	(0.3580)	(0.3020)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes	Yes
N	17262	15480	13727	12007
NCD approval marginal effect for private firms	0.01	0.03	0.05	0.09
NCD approval marginal effect for public firms	0.12***	0.21***	0.38***	0.57***
NCD differential effect (public vs. private)	0.11	0.18	0.33	0.48

Table 12. Product Market and Financing

Panels A and C present results estimating equation (1) for different subsamples, according to product market features. For Panel A, in columns I and II we split the sample according to whether firms have introduced a PMA product during the first three years in the sample, or not. Column III in Panel A includes only private firms and presents the results from a triple difference estimation according to whether private firms are PMA introducers, or not. For Panel C, in columns I and II, we split the sample according to whether firms operate in product categories with above, or below, the median fraction of publicly traded firms in a product category-year. Column III in Panel C presents the coefficients related to NCD approvals from a quadruple-difference estimation using all firms. The fourth difference is whether firms operate in a highly competitive environment, or not. Panel B replicates the multinomial logit estimation presented in Table 8 Panel B, but now interacting the dummy *NCD approval* with an indicator for when firms are 510k or PMA introducers. Controls are those included in Table 4.

Panel A: Financing and type of products introduced by firms

	510k introducers	**PMA introducers**	**Private firms sample**
Variable	**Log(Ext. fin. amount)**	**Log(Ext. Fin.Amount)**	**Log(Ext. Fin.Amount)**
NCD approval	0.1488***	0.2953**	-0.0053
	(0.0331)	(0.1214)	(0.0045)
Private*(NCD approval)	-0.1592***	-0.1967*	
	(0.0325)	(0.1074)	
PMA Introducers*(NCD approval)			0.0613***
			(0.0177)
R-squared (within)	0.0100	0.0053	0.0027
N	18555	510	18006
Effect of NCD on Private Firms:			
NCD approval + Private*(NCD approval)	-0.0112	0.0986**	
Controls	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes

Panel B: Multinomial Logit Estimation of Transaction Types for Public firms — PMA and 510k introducers

	Default option: No external financing		
Variable	**Debt**	**PIPE**	**SEO**
NCD approval*(PMA introducers)	-15.8017***	0.5336***	0.3556**
	(0.9075)	(0.1741)	(0.1747)
NCD approval*(510K introducers)	0.1782	0.2333**	-0.1942
	(0.2268)	(0.1136)	(0.1514)
Controls	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
N	1030		

Panel C: Financing and competition with high/low fraction of publicly traded firms

	High competition	Low competition	Pooled sample
Variable	**Log(Ext. Fin.Amount)**	**Log(Ext. Fin.Amount)**	**Log(Ext. Fin.Amount)**
NCD approval	0.1738***	0.3631***	0.3811***
	(0.0224)	(0.1057)	(0.0929)
Private*(NCD approval)	-0.1765***	-0.3629***	-0.3946***
	(0.0260)	(0.1140)	(0.0916)
High Competition*(NCD approval)			-0.2232**
			(0.1001)
High competition*Private			0.2326**
***(NCD approval)**			(0.1019)
R-squared (within)	0.0170	0.0131	0.0119
N	9676	9389	19065
Controls	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Product Category Cluster	Yes	Yes	Yes