# Financing Decisions of Private and Publicly Traded Firms: Evidence from a Quasi-Natural Experiment

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Abstract

We exploit Medicare national coverage reimbursement approvals of medical devices as a quasi-natural experiment to investigate how private and publicly traded firm financing decisions and product introductions respond to exogenous 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 financing of public firms. The results show why public firms have lower cost financing than private firms even in the private market. Public firms can offer private securities with better exit liquidity and lower price risk than private firms.

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# I. Introduction

Relative to being privately held, being publicly traded has both potential costs and benefits. Costs include increased costs of disclosure of information, both direct and indirect, as well as potentially larger agency problems arising from the separation of ownership and control. Offsetting these potential costs are the advantages to founders from obtaining liquidity and diversifying their wealth; and the ability to purchase other firms using IPO proceeds and liquid public stock. An additional large potential advantage of public firms is the ability to access additional external funds subsequent to improvements in investment opportunities. We investigate this potential financing advantage of public firms by examining how private and public firms' private and public financing decisions respond to exogenous changes in firms' investment opportunities.

We examine publicly traded and private firms in an ideal environment. We examine public and private firms' external financing decisions and product introductions in the medical device industry before and after Medicare approvals of national coverage reimbursement for medical devices. The advantage of looking pre- and post-Medicare approval in a product category is that these events represent exogenous changes in the potential for investment and growth for both public and private firms operating in these product categories.

Our paper is the first to study how publicly traded and privately held firms differ in the way they raise external financing when facing exogenous changes in their investment opportunities. We examine not only whether firms increase their external financing but also the type of funding — debt and equity — and the source of financing — private versus public markets. We also examine if there are differences in product introduction rates by public and private firms subsequent to the Medicare coverage decisions and firms' financing decisions

There are two potential channels through which publicly traded firms may have an advantage and lower cost of financing relative to private firms in raising external financing. First, publicly traded firms have a broader access to debt markets and external public equity financing: they can issue seasoned equity and may be able to more easily issue corporate bonds — in addition to potentially obtaining cheaper bank debt. Second, publicly traded firms may have an advantage over privately held firms even in issuing *private equity* to investors. The second channel has not been

investigated and we show that it is large. This second channel sheds light on *why* public firms have a financing cost advantage over private firms in the private equity market.

The advantages publicly traded firms have over private firms in issuing private securities arise as publicly traded firms can offer better *exit liquidity* and lower *price risk* to private investors relative to what investors can obtain by investing in private securities issued by private firms. In particular, private investors may prefer to invest in publicly traded firms through these private placements as they can liquidate their positions more easily, as public firms usually register these securities within one year. Along with this near term registration, private investors can effectively exit their positions by hedging them, even before the securities are registered: they can short sell the regular public equity in the public markets after the private security issuance is disclosed through a SEC filing. We show that the short positions in public firms issuing private securities increase after the private securities have been issued. This hedging strategy reduces the price risk of holding the private securities.

Despite these potential advantages, it is possible that publicly traded firms may respond less to better investment opportunities —and thus be unable to capitalize on their potential financing advantages — due to agency considerations or a short-term focus of managers as has been postulated by Sheen (2009) and Asker, Farre-Mensa, and Lundquist (2014). Moreover, even if agency problems or short-term focus of managers were unimportant, it is still possible that publicly traded firms may not be able to capitalize on having more financing alternatives through the public markets, as issuing in the public markets involves the disclosure of sensitive information as has been highlighted by Ali, Klasa and Yeung (2014) and Farre-Mensa (2011). Hence, understanding how publicly traded and privately held firms differ in their external financing sensitivities to investment opportunities is central to understand the advantages and disadvantages of each ownership structure.

The medical device industry is an ideal setting to test for the differences in external financing sensitivities to investment opportunities for several reasons. First, and most importantly, it is possible to identify an exogenous measure of changes to firms' investment opportunities. In the medical device industry, an exogenous demand shock occurs when Medicare approves national coverage decisions (NCD) for some devices, increasing the demand for devices in a given product

line. Second, the scale of operation of most private and public companies is small, with approximately 75% of them specializing in a single product category. Using single segment firms is important, as we can isolate external financing transactions from within-firm lending through internal capital markets. Third, this industry traditionally has relied heavily on external financing and the lifecycle of products is much shorter than in other similar medical industries (e.g. the pharmaceutical and biotechnology industries). As a consequence, small companies typically do not require the financial backing of large corporations to develop their products. Firms' financing comes almost exclusively from financial institutions or private groups of investors.

We construct our dataset by combining several data sources. From the FDA website, we identify medical device companies that have received FDA approval to introduce or modify any medical device, during 1998-2010. From this data source, we can also identify the line of business in which medical device company operates, thus identifying whether the companies are affected by a NCD decision. We hand match the company information from the FDA with firms' security issuances and bank loans from Capital IQ and Deal Scan, identifying both private and public companies.

We find that private firms use less external financing than publicly traded firms. More importantly, we find that privately held companies increase their external financing by less than public traded companies when facing a NCD decision that applies to their product line. This result is robust to the inclusion of variables that control for firms' size, productivity and technology; to different matching procedures; and to the inclusion of firm fixed-effects.

Interestingly, the *increased* probability of a public firm raising financing through a seasoned equity offering (SEO) is lower than that of a private firm raising financing through venture capital (VC) after a NCD. What drives the higher responsiveness of financing decisions of publicly traded firms is a sharp increase in public firms' issuance of private investments in public equity (PIPEs). The probability that a public firm raises funds through a PIPE transaction in a given year increases from 11.6 percent to 15.9 percent, a percentage increase of 37 percent. This difference is due to that PIPE securities offer better *exit liquidity* and *lower price risk* than private placements in private firms, as explained above.

We also show that the increased ability to raise external capital of public firms has a positive product market impact. We find that publicly traded firms operating in product categories that received a NCD approval during the sample period increase their product introduction rate by more than publicly traded firms not affected by NCDs, after the NCD approvals. Importantly, this difference is remarkably more pronounced than the difference in product introduction rates observed for private firms — affected and not affected by NCD approvals.

We contribute to the literature by being the first paper to look at the differential financing patterns by public and private firms in response to changes in exogenous investment opportunities. Prior papers have shown that publicly traded firms have an underlying advantage in terms of financing terms in the debt markets (Pagano et al (1998), Brav (2009), Schenone (2010), Saunders and Steffens (2011)). However, whether publicly traded firms could take advantage of better financing in the equity market, and in particular the private equity market, is unknown. Also whether financing responds to positive investment opportunities is unknown. In our setting, the increased external financing sensitivity to investment opportunities of publicly traded firms stems from an increase in private equity financing —a channel that was not studied before. This channel 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; retailing; pharmaceuticals, etc.). The magnitude of the differences in financing we document are quite large: conditional on observing an external financing transaction, publicly traded firms increase the amount they raise by three times more than privately held firms, after NCD approvals.

Also importantly, our paper shows that being publicly traded facilitates access to external financing even in an industry where disclosure costs are potentially high for competitive reasons. This result may be viewed as surprising given that Farre-Mensa (2011) concludes that in industries in which disclosure costs are high, access to public markets may not necessarily lead to an improvement in a firm's financing perspectives. Thus we contribute to the literature by showing that there is a financing advantage for information-sensitive publicly traded firms, which comes from a more subtle channel. The public firms' financing advantage does not come directly through their ability to issue public equity, but rather through their ability to issue private securities which

can be hedged in the public market and can be later converted into public securities. Public firms are able to share private information selectively to these private investors under an important exception to regulation Fair Disclosure (reg FD).

Our results on product introductions —which are also new to the literature — are in line with Gilje and Taillard's (2014) findings. They show that publicly traded firms have a higher investment sensitivity to investment opportunities than private firms. Our results add to the literature by showing how the financing channel —in particular that of PIPEs —affects public firms' ability to respond to improved investment opportunities.

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 (2014); Asker, Farre-Mensa and Lundquist (2014); Sheen (2009); and Maksimovic, Phillips and Yang (2013)), differences in CEO pay (Gao and Li (2013)); differences in cash holdings (Gao, Harford and Li (2013) and Farre-Mensa (2011, 2014)), differences in dividend policy (Michaely and Roberts (2012)), and differences in innovative behavior (Bernstein (2012)). Our paper sheds light on why public firms have a *financing* advantage in security issuance in private markets.

The rest of the paper is organized as follows. Section II provides background on the medical device industry and Medicare national coverage decisions (NCD). Section III describes the data. Section IV lays out the empirical methodology. Section V presents the results on financing. Section VI presents the results on product introductions. Section VII concludes.

## II. Background on 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 in 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 this industry started to receive substantial attention by the press, as effective January 1st, 2013, a 2.3% excise tax on medical devices got into effect, as part of a plan to finance the Affordable Care Act.

The medical device industry has several features that make 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). 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. pharmaceutical industry). Thus, companies do not typically require the financial backing of large corporations to develop their products. As a consequence, their financing comes almost exclusively from financial institutions and investors, and not from strategic partners.

### *A. 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 510(k) 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 new modality need to be different to the existing devices in some respects (e.g., more

accurate, faster, etc.), to avoid violating patent law.[1] However, if a *medium risk* device is not substantially equivalent to an existing device that undergoes the 510(k) process, the PMA process applies.

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

### *B. 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 elderly population in the U.S.[2]

Medicare is composed of 4 parts: Parts A to D. The program started in 1965 offering only Part A. Part A covers hospital and impatient 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 recently entered into effect in 2006 — provides prescription drug coverage. In 2010, the program spending was $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 health providers. Typically, Medicare sets in advance the prospective payments amounts that health providers will receive for services provided to Medicare enrollees.[3] After service is provided, Medicare's fiscal agents pay the health providers the predetermined rates minus the beneficiaries' cost-sharing liabilities. For Medicare Part B the cost-sharing liability consists of a small deductible and a 20% co-payment (see Finkelstein and McKnight 2008).[4] About 50% of Medicare beneficiaries complement their coverage with other

[1] See, for example, Sunrise Medical HHG Inc. v. AirSep Corp.
[2] To be eligible individuals or their spouses need to have worked 40 quarters or more in covered employment.
[3] These payments differ by region, as costs of service might vary with geographic location.
[4] 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/publications/congressional_reports/mar02_ch1.pdf

insurances, such as Medigap or health insurance programs provided by their employers (see Card et al. 2008).

### *C. Medicare Coverage Decisions*

The Centers for Medicare and Medicare Services (CMS) chooses to make national coverage decisions (NCD) only when there is a major expected impact in the program, or there are cost, quality and safety concerns (see Neumann et al 2008; and Tunis et al. 2011). There are 3 NCDs categories: Medical Devices, laboratory/diagnostic tests and medical procedures. Examples of NCDs that have attracted general attention include the approval of the lung-volume reduction surgery — a medical procedure — and the approval of coverage for additional uses of implantable cardioverter defibrillators — a medical device — (see Gillik 2004).

The request of a national coverage decision can be generated internally by the CMS, or externally by interested parties such as medical associations.[5] A NCD approval is arguably an *exogenous* shock to a firm's investment opportunities as 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 — as described in the data section — to companies that operate in a single product category with annual sales under $300 million.

The approval rate after these requests for national coverage 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.

Regarding medical devices, NCD approvals 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

[5] 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.

device. The approved devices almost invariably need to be FDA approved.[6] 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 NCD can be found in the CMS' website. In the medical device category (i.e., durable medical equipment and prosthetic devices), between 1998 and 2010, the CMS issued 17 NCD approvals for 12 devices.[7] There are more approvals than devices, as some devices where subsequently approved for additional uses during the sample period. Table 1 summarizes CMS's NCD approvals for 1998-2010. Column 1 shows the FDA product category of each device. Column 2 shows the name of the device that obtained national coverage approval. Column 3 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 some initial coverage was approved before 1998. Columns 4 and 5 show the year in which some of the devices obtained extended coverage during the sample period. Column 6 shows the year in which the device was initially approved, in case the initial approval was prior 1998. Column 7 shows the review process under which manufacturers need to submit their applications to get FDA approval on each device. Table 1, Panel B, shows the product categories that did not receive any NCD approval/extension during the sample period (1998-2010) that we use as our control group.

**Table 1 here**

To further clarify the content of Table 1, we describe the NCD approval process for two devices: the Implantable Automatic Defibrillators (IAD) and the Neuromuscular Electrical Stimulation (NMES). The history of NCDs for IAD is fairly long. IAD is an electronic device which was initially designed to detect and treat life-threatening tachyarrhythmia. For its use, it needs to be implanted in the patient. In 1986, CMS approved its coverage as last resort for patients who have had a documented episode of life-threatening ventricular tachyarrhythmia or cardiac arrest not

[6] Although not a 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. See http://www.theheart.org/article/198579.do

[7] This number does not include NCD approvals of medical devices for their exclusive use on medical trials (2 cases).

associated with myocardial infarction. Effective in 1999, the CMS extended coverage for patients with a documented episode of cardiac arrest due to ventricular fibrillation not due to a transient or reversible cause; with ventricular tachyarrhythmia, either spontaneous or induced, not due to a transient or reversible cause; or with familial or inherited conditions with a high risk or life-threatening ventricular tachyarrhythmia such as long QT syndrome or hypertrophic cardiomyopathy. In 2003, the CMS approved extended coverage for coronary artery disease with a prior myocardial infraction, sustained ventricular tachyarrhythmia and other technical specifications. In 2004, the CMS relaxed the technical conditions specified in 2003 and further extend the coverage for this device. The CMS's NCD approval of NMES, on the other hand, is much shorter. NMES involves the use of a device which transmits an electrical impulse to the skin over selected muscle groups by way of electrodes. In 2002, the CMS approved its use for the treatment of spinal cord injuries for patients to aid in walking.

A 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 more 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, CPAP hoses, etc.

### *D. Economic Relevance of NCDs*

In Table 1, Panel C, we present evidence on an event study of NCD approvals on public firms' returns. We provide this evidence to establish that these events are of large consequence for the firms in this industry. 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 a few days, or months, after the memo is released.

We complement the evidence presented in Table 1, Panel C, with Figure 1. The Figure displays the distribution of entry (number of firms founded) for product line-years with and without NCD approvals. The Figure shows that a higher proportion of entry occurred in product line-years in which NCD were approved. In particular, the median number of firms entering in a product-category year with and without a NCD approvals are 3 and 2, respectively. The difference in median number of entrants is statistically different at the 10% level (p-value of 7%). This supports the idea that NCDs also benefit privately held firms, as 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. All in all, the evidence presented in Panel C and Figure 1 shows that NCD are of large economic relevance for both publicly traded and privately held firms.

**Figure 1 here**

## III. Data

We construct our data using four data sources: the Food and Drug Administration (FDA) website, Capital IQ, Hoovers, and DealScan. 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 this data. 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 510(k) processes). The FDA classifies medical devices into 19 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 single product category. We do so, to isolate effect of the NCD approvals — which are product category specific— on firms' financing decisions. From Capital IQ we obtain firms' fund raising transactions, such as SEO, fixed-income offerings, PIPEs, VC, etc. From DealScan we obtain information on bank loans.[8]

Ideally, we would like to have information on a firm's assets or sales on a yearly basis to control for the correlation between firms' size and external financing transactions. Unfortunately, that information is not available for private firms.[9] However, Hoovers and Capital IQ contain information for firms' last year sales, both for private and public companies. 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.

Firms' need for external financing may also correlate with their age. Typically, older firms are more capable of using internal funds to invest, while younger firms depend more on external financing. To control for age we obtain information on firms' founding years from Capital IQ. We also obtain data on firms' 2011 employees. We use this variable to construct measures of firms' productivity: sales per employee and products introduced per employee.

From Capital IQ, we can also 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

[8] 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.

[9] 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 (2013) and Gao, Harford and Li (2013)). For the vast majority of the companies in our data this information is not available.

companies. Second, large public companies may lobby for the approval of NCD decisions raising concerns about the exogeneity of NCD approvals on those large firms' external financing transactions. We exclude 54 firms with more than $300 million in sales given this criteria.[10]

Our final data set is an unbalanced panel containing 19,105 firm-year observations for 1,806 companies. Of these, 17,812 observations belonging to 1,708 firms correspond to private firms, and 1,293 observations belonging to 118 firms correspond to publicly traded companies.[11] The panel is unbalanced for two reasons. First, 727 companies were founded during our sample period. Second, 219 companies were acquired as subsidiaries by larger firms prior to the end of the sample period. As we do not consider operating subsidiaries in our sample, we drop the acquired company observations after the acquisition. For these companies, the reported sales consist of the division that the company represents in the parent company.

### *A. Summary Statistics*

Table 2 provides the summary statistics of 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 0; if it does, it takes the transaction amount. *External Financing Transaction* is an indicator variable that takes a value of 1 if a firm obtains external financing in a year, and 0 otherwise. The variable *Private* is an indicator variable which takes a value of 0 if a company was publicly listed in a year, and 1 otherwise.

**Table 2 here**

*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* (510 (k)) is the number of FDA approved products to a firm in a year, which are substantially equivalent to other existing products of *medium* risk in the market. *Products per year* (PMA) is the number of FDA approved products to a firm in

[10] Our results hold if we allow for less stringent cutoffs, e.g. $500 million, $1000 million, etc. However, introducing larger companies in the sample raises identification concerns, as large companies are more likely to participate in lobbying activities.

[11] The sum of private and public companies is higher than the total, as there a few companies that changed their listing status during the sample period.

a year, which underwent Pre Market Approval (i.e., high risk devices), and are typically not equivalent to existing products. 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.

The variable *NCD Approval* takes a value of 1 if a firm operates in product category that received a NCD approval, for the NCD year itself and the next 3 years, and 0 otherwise. If more than one NCD approval overlap in time in a given product category, the variable takes the sum of the NCD approval shocks for the overlapping window. For example, for firms in the Neurology category, which had NCD approvals on 1999 and 2002, *NCD Approval* takes a value of 0 for 1998; 1 between 1999 and 2001; 2 in 2002 (as this is the third year after the first NCD approval, and also the year of the second NCD approval); 1 between 2003 and 2005; and 0 again from 2006 onwards. We choose to define NCD approvals shocks using a four-year window (t=0 to t=+3) as our data analysis shows that firms increase in financing activity can last up to three years after a NCD approval — see section V.c for the study of the timing of financing.[12]

### *B. 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 for private companies, representing 68% of the deals. Private equity investments, sometimes referred to as growth capital, are the second most frequent used source of external financing for privately held firms, representing 22% of the deals. Bank loans transactions are observed less frequently. This is to be expected as even for public firms, the median (mean) industry leverage is just 3% (10%).[13] 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.

[12] Alternative definitions of NCD Approval shocks yield similar results. In a prior version we defined NCD approvals as permanent shocks, leading to identical conclusions. Also, in Section V.c, we show that defining NCD as single period shocks also leads to analogous results.

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

**Table 3 here**

Regarding IPOs, 22 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 designate 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.[14] Notice that while 22 firms going public seems low in comparison to the number of private firms, they represent a large fraction of firms that were already public (23%), as there were 96 public firms initially (there were 118 public firms by the end of the sample with 22 IPOs during the sample period).

Table 3, Panel B, shows the transaction types and average dollar value per transactions 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 65% of the transactions. The fact that around 80% of the non-debt transactions (148 out of 185) are done through private markets relates to the small size of public firms in our sample (the mean size of sales is US $13 million), 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 issuances (equity and convertibles) are in the private markets.[15]

Relative to offerings in public markets, private offerings have the advantage that the issuer can provide new selective information to investors. Securities disclosure laws, including Regulation *FD*, exempt communications by the firm from the disclosure restrictions when those communications are to investors who "have expressly agreed to maintain the communication in confidence pursuant to a confidentiality agreement" (Houston and Laitin 2000). New information

[14] Our results hold even if we classify the money raised as obtained by privately held firms (i.e., if the indicator variable *Private* takes a value of 1, instead of 0, during the IPO year). In other words, the way we define the ownership status during the IPO year does not drive the results.

[15] The fact that the fraction of private issuances in the medical decide industry is slightly larger than the average across all industries is most likely due to the high costs of disclosing information, which we postulate is for competitive reasons.

can be learned by investors if they have one-on-one meetings with the issuer's managers and employees and/or visit the issuer's facilities. The process holds both for private firms and for public firms selling private securities through PIPEs.[16] Moreover, given the concentrated stakes taken by some investors in private placements, issuers have more incentives to expend effort into producing valuable information. Investors are likely to invest in industries in which they have expertise and thus are more able to process and interpret the information gathered during the due diligence process.

Despite these similarities of private securities issued by public and private firms, there are important advantages of private securities issued by publicly traded firms (PIPEs) over private securities by private companies. First, PIPE securities are much more liquid than private securities, as they are typically registered with the SEC within six to twelve months, allowing private investors to sell these securities in the regular public markets once they have become registered. The securities also contain "piggyback" registration rights that require the company to register the securities before selling any other stock and 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 issuance of World Heart Corp, Jan 2010).[17] Once registered, the stock becomes identical to regular publicly traded equity and can be sold in the public market.

The second main advantage of PIPE securities is that 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 such as an 8K or 13D. Consistent with the notion that PIPE investors diversity their risk prior to security registration Brophy, Ouimet and

[16] The informational advantage of PIPE securities, relative to public offerings made by public firms, is documented in Gomes and Phillips (2012). Another advantage for public issuers of issuing privately is that the transaction is faster to implement (see Chaplisnksy and Hausenhalter, 2010). The benefits of issuing privately (i.e., selective release of information and shorter issuance time) have to be trade-off against the price discount at which PIPEs are issued, relative to SEOs.

[17] The PIPE terms can be found in documents filed with the SEC. For example, in an 8k 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
In the correspondent 13D schedule —Item 6 — they mention piggy-back registration rights: http://www.sec.gov/Archives/edgar/data/1024520/000119312510022178/dsc13da.htm

Sialm (2009) show that short selling is significant in the public equity of a firm, after that firm has issued a private equity security. This is also the case for our sample. Figure 2 shows that shortly after a PIPE deal is closed, short interest increases substantially.

**Figure 2**

Overall, PIPE investments may thus be relatively more attractive to private investors who value liquidity than investments in the form of private equity (VC and PE) in privately held companies, as they offer better *exit liquidity* and lower *price risk* to investors.

***C. Univariate Analysis***

In Table 4, Panel A, we compare the variable means for privately held and publicly traded companies. The table shows some differences between private and public companies, as expected, given that the choice of listing status is nonrandom. Although we are not interested in the differences in companies trading status *per se*, but rather on how they differ in their financing sensitivities following a shock to their investment opportunities, the lack of random assignment between groups raises some concerns. In particular, one may worry that if we were to find that publicly traded and privately held firms differ in their external financing sensitivity to investment opportunities, this maybe because they are somewhat different in their technology, productivity, or type of products produced — and not necessarily due to their trading status. We take several approaches to mitigate this concern.

**Table 4 here**

First, we work with two subsamples of matched companies, using two different matching procedures. For each of these 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 to capture differences related to firms' size and life cycle; matching on different types of products introduced helps to match on firms' technology: firms producing more PMA products, which are more novel and riskier, may have a different cost structure than firms introducing more products which are substantially equivalent to others through the 510(k) submission process. Finally, matching by sales per employee and total products

introduced per employee helps to mitigate concerns regarding differences on firms' productivity, differing stages of commercialization and product development among public and private firms.

Our first matching procedure is suitable for within-firm analysis, as it follows matched pairs through time (similar to Asker et al. 2014; and Gilje and Taillard 2014). We first consider only those publicly traded firms that operate during the 13 years of the sample (74 firms). Then, we match them to an equal number of private firms that also operate for all 13 years, according to their 1998 characteristics, using propensity matching score.[18] Thus, we follow the matched pair over time. We lose 14 public firms as there were no private firms with common support in the distribution. Our final sample consists of 60 matched pairs that operate through the whole sample period. The univariate differences for this subsample are presented in Table 4, Panel B. For this subsample most of the observable differences between groups —for variables other than external financing — are greatly reduced relative to the overall sample.

Our second matching procedure matches at the observation (firm-year) level. While this matching procedure does not follow firms pairs through time — and thus is less suitable for firm fixed effect regressions — it does have the advantage of being more accurate: for each public firm-year *observation* we select the nearest-neighbor match using propensity score matching. Using this matching procedure, it is also the case a few publicly listed firm-year observations could not be matched due to lack of common support in the distributions. The univariate differences for this matched sample are presented in Table 4, Panel C. As can be seen, the observable differences between groups —for variables other than external financing — are greatly reduced in this matched sample.

To further mitigate concerns regarding nonrandom assignment, in our empirical specification we also control for the variables used in the matching procedure —even when using matched samples — and interact these controls with the *NCD Approval* (investment opportunity) shock. The interactions helps to address the concern that small differences in size, age, technology or

[18] 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.

productivity, is what may cause differences in external financing sensitivity, and not the listing status itself.

We recognize that it is not possible to completely eliminate any concerns that unobservable characteristics drive selection and the differential external financing sensitivities we measure without an experiment that generates full random assignment. However, the quasi-natural experiment we utilize to obtain exogenous shocks to investment opportunities and the steps we take in terms of matching and controlling for investment opportunities and firm productivity mitigate these concerns.

What we are examining is thus whether being publicly traded enables firms to get lower cost financing in both the public and private markets to better exploit opportunities. In support of this proposition, we document earlier that 22 firms go public during our sample period, representing 23% of the existing public firms. In our later results, we show private firms are more likely to go public after NCDs (these results are shown and discussed later — see Table 8). This suggests that firms are willing to bear the cost of being publicly traded in order to access better financing opportunities.

## IV. Empirical Strategy

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

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

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 parameter $\beta$ captures the 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 $\gamma$ captures the effect of NCD approvals on external financing

activities. 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 $\delta$. This parameter tells us whether private or public companies differ in their sensitivity to investment opportunities. If $\delta$ is negative, private companies raise less external financing than publicly traded companies when facing better investment opportunities.

Key to our identification of the above parameters is that the differences between privately held and publicly traded companies are not driven by other characteristics that correlate with a firm's trading status. To address this concern, we include a set of controls **X**, which contains the number of products introduced in a year, both through the 510(k) and PMA submission processes, to capture for firms' size and technology. It also contains firms' sales to further control for firm size. This set of controls also includes firms' age, as younger firms typically require more external financing than more mature firms; and measures of firms' productivity, such as *Products per year/Employee* and *Sales/Employee*. As mentioned above, for some specifications we also interact these variables with the variable *NCD Approval* to show that the results are not driven by the interaction of an increase in investment opportunities with variables that correlate with a firm's trading status.

In all our specifications we include year fixed effects, $\mu_t$, to control for unobserved macro shocks that may correlate with firms' financing activities (e.g., aggregate demand shocks, costs of funds, etc.). We estimate our main results using firm fixed effects, $\varphi_i$, to mitigate potential unobserved heterogeneity concerns, as this specification only exploits within firm variation. In this specification the coefficients of the variables *Age*, and *Log(sales) and Sales per Employee* cannot be estimated; however, the interaction between *NCD Approval* and these variables can be included, as *NCD Approval* is time-variant.[19] In some specifications we estimate non-lineal models, such as Tobit, or Probit. For these specifications, firm fixed effects are not included, as their inclusion leads to inconsistent parameters.

We first estimate equation (1) using the full sample of public and private firms. As mentioned in Section III, we also replicate our estimation of equation (1) using two set of matched samples: one

[19] The variable *Age* increases by 1 for all firms every year, so it is perfectly collinear with the constant term.

that maximizes the accuracy of the match, and another which is more suitable for the analysis of within firm variation. The estimations with matched data also help scaling firms' external financing transactions to their relevant characteristics, such as size and age.

In all specifications we adjust standard errors for heteroscedasticity and product-line clustering. We cluster at the product-line level as demand shocks are at this level of aggregation. This clustering strategy accounts for 3 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 within the same firm over time (see Petersen 2009).

## V. Financing Results

### *A. Main Results*

Table 5 presents regressions examining external financing sensitivity to NCD approvals. Panel A presents regressions examining external financing transactions amounts and Panel B presents regressions examining the likelihood of an external financing transaction. Columns I and II present the results using the full sample; columns III and IV present the results for the sample matched on initial observations; and columns V and VI present the results for the sample matched on firm-year observations. Specifications shown in columns II, IV and VI differ from those in columns I, III and V, in that they also include the interaction of the control variables with the NCD shock.

**Table 5 here**

All the specifications show similar results: NCD approvals have a strong positive effect on external financing, indicating the 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 II. 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. The coefficient of the interaction term is negative, in spite of a potential bias in the other direction. Prior papers, such as Gao, Harford and

Li (2013) and Farre-Mensa (2011, 2014), document that public firms hold more cash than privately held firms. For this reason, public firms may need less external financing than private firms to respond to improved investment opportunities. Thus, the coefficient we find on the interaction term can be considered a lower bound of the true coefficient that captures the differential external financing response of private and public firms to improved investment opportunities.

The results also show a negative coefficient for the dummy *Private*.[20] This implies that privately held companies obtain external financing much less frequently —and in smaller amounts — than publicly traded companies. This result is consistent with Brav's (2009) findings that privately held firms rely less in external financing. Importantly, as noted above, we can go one step further and document that public firms also react more to investment opportunities by raising additional funds when they are needed more. Thus, we are the first to document that publicly traded firms have a higher external financing sensitivity to investment opportunities. This finding is novel to the literature.

In column VII, of Panel A, we present the results from a Tobit estimation, for robustness, as the variable *Log(Ext. Financing Amount)* contains an important fraction of observations with zero values (i.e, when no external financing transaction occurred). Also, in column VII, of Panel B, we replicate the results of the linear probability model on *Ext. Financing Transaction* using a Probit model. All the results hold.[21]

***B. Economic Effects***

The economic effects of NCD approvals, for public and private firms, are summarized in Table 6. We consider the economic effect of a 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 5. The first and the second effects are obtained from OLS regressions (Table 5, Panels A and B, column I), the third effect is computed from the Tobit specification (Table 5, Panel A, column VII).

[20] Given that our main specifications uses firm fixed effects, the coefficient of the dummy *Private* is identified by the 22 firms that underwent an IPO during the sample period. However, the coefficient remains negative and statistically significant even if we drop firm fixed effects from the estimations.

[21] Estimates from matched samples are qualitatively similar for Tobit and Probit regressions.

**Table 6 here**

Our results indicate that for public firms, a NCD approval leads to a 19.1% unconditional increase in external funds raised; and a 6.2% increase in the probability of raising funds externally in a year. For private firms, the results are more modest: a NCD approval leads to a 0.7% unconditional increase in external funds raised; and a 0.2% 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. To the extent that this under sampling is somehow more severe for the fraction of private firms affected by a 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 a NCD on the amount raised, conditional on observing an external financing transaction. This estimate can be obtained from the Tobit specification. This estimate is not affected by sample selection, to the extent that, conditional on a deal being reported, there is no systematic bias in the amounts reported (there is no reason to believe deal amounts are misreported). The results indicate that, conditional on observing an external financing transaction, private firms increase the external financing amount by 4.4% after an NCD approval, while publicly traded firms do by 15.3% (more than three times larger), and both are statistically significant at conventional levels. The difference in amount raised between publicly traded and privately held firms is still quite large in this specification (close to 11%) and statistically significant at the 1% level. Thus, the differences in external financing sensitivity we document cannot be attributed to deal reporting issues.

### *C. Timing of Financing*

In this section, we study the timing of financing relative to NCD approvals. Doing this is useful for two purposes. First, we can check whether the difference in external financing between private and public firms was widening the years prior a NCD approval. If that was the case, then we cannot rule out that the difference in external financing sensitivity to NCDs we find in our prior results is simply a consequence of prior ongoing trends. The finding of no significant differential effect of

a NCD for the years prior to the actual NCD, however, would provide support for the parallel trends assumption that we have been implicitly maintaining so far in our empirical analysis.

Second, we can study the length of the effect of NCD approvals on firms' external financing. Our definition of the *NCD Approval* variable assumes that NCDs may have an effect on external financing during the NCD approval year and the three following years. By studying the exact timing of the financing events we intend to provide further justification to our chosen time window.

In particular, redefining NCD approvals as single-period dummies, we study public and private firms' external financing, from four periods prior to a NCD to four periods after, using the following specification:

$$(1)\ y_{it} = \alpha + \beta * Private_{it} + \sum_{\tau=-4}^{+4} \gamma_\tau * dummyNCD_{it+\tau} + \sum_{\tau=-4}^{+4} \partial_\tau * Private_{it} * dummyNCD_{it+\tau} + \varphi_i + \mu_t + \varepsilon_{it}$$

The results are shown in Table 7. Column I shows the results using *Log(Ext. Financing Amount)* as explanatory variable, while column II shows the results for *Ext. Financing Transaction.* As the table shows, none of the coefficients of *NCD Approval dummies* are significant in the years prior to the NCD, and they are all significant starting on the NCD approval year until three years after, consistent with our definition of the *NCD Approval* variable. Thus, it seems like a NCD approval leads to firms raising additional funds during a four-year window.

**Table 7 here**

The interaction between the dummy *Private* and the NCD approval dummies is insignificant for all years prior to the NCD shock, except the year just before a NCD approval. These findings thus provide evidence that the differential financing results we document are not due to prior ongoing trends, although there seems to be a slight anticipation to NCD approvals. This is most likely due to the fact that a proposed decision memo for NCD approvals sometimes starts circulating a few months prior to the final decision memo.

Overall our results are very robust. They all indicate that publicly traded companies raise more external funds than privately held firms in the presence of improved investing opportunities. In the next section, we study the channel under which this financing advantage occurs.

### *D. Which Securities Give the Financing Advantage to Publicly Traded Firms?*

In this section we study through which securities the financing advantage is occurring. We estimate a multinomial logit of security issuance using NCD approvals as 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 the IPO decision as taken by a privately held company, as the decision of undergoing 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. The results show that private companies have a statistically significant increase in venture capital and IPOs after a NCD approval. However, the estimated marginal effects are small. The reason for the low economic importance is that receiving venture capital and going public are low frequency events relative to the large number of private firm-observations (relative to the number of public firms, IPOs represent a large 23% of the public firms at the beginning of our sample). One question that arises is why even more private firms don't get venture capital, growth capital, or go public. There are multiple potential reasons. First, the owners of private firms may not want to dilute their ownership stakes. Second, with respect to IPOs, it may take too long to register with the SEC and go public, such that the benefits of the NCD decision may already accrue to the existing public firms.

**Table 8 here**

Publicly traded firms, on the other hand, have a sharp increase in private investments in public equity (PIPEs), which is economically large: 37% — the probability that a firm raises funds through a PIPE transaction in a given year increases from 11.6% to 15.9%. Overall, the results indicate that PIPEs —which represent 65% of the transactions for public companies— are driving the result that public firms react more to better investment opportunities than private firms. These results suggest that the advantage of being public for smaller public firms does not come from having better access to public markets, but rather to being able to offer liquid securities that private

investors can easily sell later. As discussed earlier, when these securities are offered to private investors, the offering includes registration rights that require the company to register the securities with any public offering of stock and frequently has clauses that give the private investor more equity (payment-in-kind) if the security is not registered within a given period of time. Once registered these equity securities become identical to already traded public equity and shares are able to be sold in the public markets. Lastly, private investors can hedge the risk of these PIPE securities by shorting the publicly traded stock once the company discloses the sale in a filing with the SEC. Thus, while not initially sold in the public market, the existence of publicly traded equity is important.

To shed more light on our interpretation, we look for the description of some of the PIPE transactions in which firms affected by a NCD approval raised funds. This information is shown in Appendix A. The descriptions of the deals tend to highlight the availability of an "exit option" for investors. The securities issued in these transactions frequently contain these explicit conversion rights which allow private investors to convert into public equity at a later date, thus proving future liquidity to these investors.

We thus document a financing advantage that has not been shown before —through private equity — and that the financing advantage is shown to be at work precisely when funds are needed more — after a positive investment opportunity shock. In addition, the economic magnitude of our results is quite large. We document that, conditional on observing an external financing transaction, public firms raise 15.3% more funds after a NCD, while private firms only raise 4.4% more funds. That is, the effect of an investment opportunity shock on financing is more than three times as large for publicly traded firms than for privately held firms. To put these numbers into context, prior papers have shown that when publicly traded choose to raise funds through debt (without controlling for changes in their investment opportunities, though), they obtain lower rates than privately held firms. In particular, Schenone (2010) and Saunders and Steffens (2011) document that public firms obtain loans at 25-35 basis points lower than equivalent private firms, which represents a 10-15% reduction in the spread. The magnitude of the effect we document is large relative to these previously documented findings in the debt markets. We show that there is

a 300% increase in the amount of external financing, the vast majority of which in is the equity markets, something that has not been shown previously.

### *E. Acquisition Activity*

In our prior results, we show that privately held firms raise less funds than similar publicly traded firms, in the presence of improved investment opportunities. One possible explanation is that private firms raise fewer funds simply because they are more likely to be acquired after NCD approvals in their product lines. We analyze this possibility by estimating a multinomial logit regression 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 it acquires another firm. The results are shown in Table 9. Panel A shows the results for privately held firms and Panel B shows the results for publicly traded companies. The results show that neither private nor public firms are significantly more or less likely to be acquired or to acquire after NCDs. Our results thus do not support the proposition that private firms are acquired after NCD approvals as a substitute for raising external capital.

**Table 9 here**

The fact that NCD approvals shock have an important impact on financing — and product introduction as we see below — but not on acquisitions is likely to be due to the focused nature of the firms in our sample. As described in Section II, most firms in the medical device industries are small and operate in a single product category. Given their focused nature, firms in our sample 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.

## VI. NCDs and Product Introductions

### *A. Product Introductions*

While our prior results establish a relation between investment opportunities and different financing patterns of public and private firms, they do not address the consequences of obtaining additional financing. In principle, companies should use the 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 firms' R&D or capital expenditures to

directly test for this. However, we do have data on firms' FDA approved product introductions/modifications. Therefore, we study whether product introductions (or modifications of existing products), which are a long-run consequence of investments, are differentially affected for privately held and publicly traded firms.

We first examine graphically the differences in product introductions in Figures 3 and 4, followed by multivariate regression analysis where we use a negative binomial model to examine the number of product introductions following NCD approval decisions. Figure 3 shows the evolution of product introductions (both through the 510(k) and PMA submission processes) for four groups of firms: publicly traded firms operating in a product line that did not receive a NCD approval during 1998-2010; publicly traded firms operating in a product line that received one (or more) NCD approval(s) during 1998-2010; privately held firms operating in a product line that did not receive a NCD approval during 1998-2010; and privately held firms operating in a product line that received one (or more) NCD approval(s) during 1998-2010. We set the growth rate equal to 1 for all groups in 1998, and for each group-year we add the average within-firm product introduction yearly growth rate to plot each group's product introduction trend over the sample period. The figure shows that publicly traded firms operating in product categories that received a NCD approval during the sample period increase their product introduction rate by more than publicly traded firms not affected by NCDs. Importantly, this difference is remarkably more pronounced than the difference in product introduction rates observed for private firms — affected and not affected by NCD approvals. Thus, NCD approvals have a differential effect on product introduction among publicly traded and privately held firms. This is consistent with publicly traded firms being able to capitalize on their external financing advantage over privately held firms.

**Figures 3 and 4 here**

Although Figure 3 shows substantial differences in product introduction growth rates among privately held and publicly traded firms — both affected and unaffected by NCD approvals — it is still possible that these differences were driven by prior trends. Perhaps publicly traded firms affected by NCD approvals were growing faster than firms in the other groups, even prior to NCD approvals. In that case, the faster growth rate displayed by publicly traded firms affected by NCD

approvals should not be considered as evidence of NCD approvals causing higher product introduction rates, through any channel.

To address the issue related with potentially pre-existing trends, we replicate Figure 3, but considering only a subset of firms that received NCD approvals in a single year, during a fairly long time period: we only include firms in the Anesthesiology and Gastroenterology/Urology product categories. These product categories received NCD approvals in 2001, and had no NCD approvals either between 1998 and 2001, or from 2002 to 2007, giving us enough pre *and* post *treatment* years to analyze product introduction trends. The product introduction trends are shown in Figure 4.[22]

Figure 4 shows that publicly traded firms in the *treated* product categories do not have any indication of higher product introduction growth rates, prior to 2001, than firms in the other groups. This implies that the differential effect of NCDs on product introduction rates for public and private firms cannot be attributed to prior ongoing trends. Actually, only 2-3 years *after* the NCD approval is when publicly traded firms in the Anesthesiology and Gastroenterology/Urology categories have a change in their product introduction trend. This delay is consistent with the timings in the medical device industry: It usually takes about 12-24 months to produce device improvements, between 6-24 months to obtain FDA approval on product introductions/modifications, and financing may come with delay, too.

Lastly we examine new 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}. 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 run negative binomial regressions. The results are shown in Table 10. Panel A shows results using total product introduction as dependent variable. Panels B shows results using as dependent variable firms' number of products introduced which underwent the FDA 510(k) approval process. These type of products are typically of intermediate risk (to its user), and in order to get FDA

[22] This type of figure is often referred to as "dynamic graph" in a Diff-in-Diff analysis.

approval, the manufacturer only needs to prove that their device is substantially equivalent to other existing products. Panel C repeats the analysis using PMA product introductions (i.e., high-risk products which are more innovative and cannot be claimed to be substantially equivalent to existing products). Exploring the differences between each type of product introduction can help to understand product market competition features of the industry. The economic effects are shown in the bottom rows of each panel.

**Table 10 here**

The results from Panel A 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 introduction between private and public firms widens after NCD approvals. Overall, the higher product introduction that publicly traded firms display after a NCD approval is consistent with Figures 3 and 4. It is also consistent with public firms having a financing advantage, as these firms have better access to external funds when investment opportunities improve.

Panel B shows that while public firms tend to increase their product introduction of 510(k) products after a NCD approval, private firms do not. Private firms actually reduce slightly their product introduction. This evidence thus suggest that when it comes to improving existing products, there seems to be a "winners takes all" effect in the industry: firms that have more financial resources can take full advantage of the investment opportunity, while private firms, which typically hold less cash and use external financing to a lesser extent, cannot benefit at all. Panel C shows that both private and public firms introduce more novel and riskier (PMA) products to the market after a NCD approval. Thus, there seems to be scope for innovation (and market expansion) for both set of firms, albeit to different extents given the financing advantage of publicly traded firms.

Our findings on 510(k) and PMA product introductions help to understand why private firms do not seem to get substantial additional funds through bank loans after a NCD approval — on top of the general fact that debt financing is not very common in this industry. Private firms appear to benefit from NCD approvals, in terms of risky investment opportunities (PMA introductions), but this type of investment is not well-suited for debt finance. Also, there seems to be a "winners take all" type of competition among investments of relatively lower risk —product modifications. Thus

private firms do not seem to benefit from "low" risk investment opportunities after a NCD approval, which would be more amenable to debt financing.

### *B. Agency Concerns*

So far, our findings on financing and on product introductions are consistent with publicly traded firms having a financing advantage. However, this does not rule out the possibility that, due to agency problems, publicly traded firms may still use their financing advantage to over-invest, rather than to invest efficiently. While this concern is mitigated by the fact that stock prices of firms affected by NCD approvals respond favorably (see Table 1 Panel C), it is still possible that there is scope for over-investment, on the margin. To shed more light on this matter, we obtain data on projected market sizes for each product category. To the extent that more introductions positively correlate with market size, we would be less concern that introducing products is an indication of excessive investments, as the profitability of a new product is expected to be increasing in the potential size of its market.

We replicate the specification from Panel A, adding as an additional regressor the variable *Category Size*, which is the 2015 projected relative (to the industry) market size of the category (in dollar value), in which a firm operates. In addition, we include as additional regressors the interaction between the *Category Size* variable and our key variables of interest — *Private*, *NCD Approval*, and *Private*NCD Approval* — to explore whether publicly traded firms and privately held firms differ in their investment sensitivities to NCD approvals, according to market size. The results from this last analysis are reported in Panel D.

The results show that category size positively correlates with product introductions, indicating that more products are introduced in categories that are more likely of higher profitability. The results also show that, if anything, privately held firms tend to increase their product introduction by more than public firms, following a NCD, if they operate in a larger category (i.e., the coefficient of *Private*NCD Approval*Category Size* is positive, although statistically insignificant). While only suggestive, our results do not find indicative evidence that publicly traded firms are using their funds to over-invest.

## VII. Conclusions

We examine the financing decisions and product introductions of private and public firms after exogenous changes to their investment opportunities in the medical device industry. The medical device industry is an ideal industry to examine whether being publicly traded confers advantages or disadvantages as this industry contains over 1,800 small private and public firms that produce in a single product category. We use Medicare national coverage decisions as exogenous shocks to firms' investment opportunities. Medicare national coverage approval decisions for national coverage represent large positive shocks to product demand for both publicly traded and private firms. We find that public companies increase their external financing and introduce more products than private companies in response to these national coverage approvals. Our results are robust to the inclusion of variables that control for firm size, technology and productivity, to different matching procedures, and to the inclusion of firm fixed-effects.

We show that private market securities issued by public firms explain why publicly traded firms have a higher financing response to these Medicare coverage decisions. Public firms have a sharp increase in private investments in public equity (PIPEs) post-NCD approval of 37 percent. Interestingly, the increased probability of a public firm raising financing through a seasoned equity offering (SEO) is lower than that of a private firm raising financing through venture capital (VC) or private equity after a NCD. These findings are unique as previous authors have focused on why being publicly traded may give you a lower cost of financing in the debt markets. We document an advantage in the equity markets and highlight why that there is lower cost financing for public firms in the private equity markets.

In our setting, publicly traded firms' financing advantage comes from offering equity securities with better exit liquidity and less price risk in the *private equity markets.* Private equity in public firms offers better *exit liquidity* than private placements in private firms, as these securities are typically registered with the SEC within six months to one year, allowing private investors to sell them when they are registered. PIPE securities also offer lower *price risk* than private placements in private firms, as private investors have a benchmark public reference price and they can hedge their risk in these securities by selling the public equity short in the period prior to the securities being registered. In contrast, private investments in privately held companies have more price risk

and are relatively more difficult to sell than PIPEs. Our results are consistent with these features making investment in publicly traded companies through private equity more attractive to private investors that value liquidity and reduced price risk.

Overall, our results are consistent with an important financing advantage of public firms that allows them to take advantage of positive exogenous changes in investment opportunities. This financing advantage that persists in the private equity markets allows publicly traded firms to introduce more new products in the face of better product market opportunities. Thus firms should take this financing advantage into consideration when deciding whether to go public, given the issuance and agency costs associated with public ownership.

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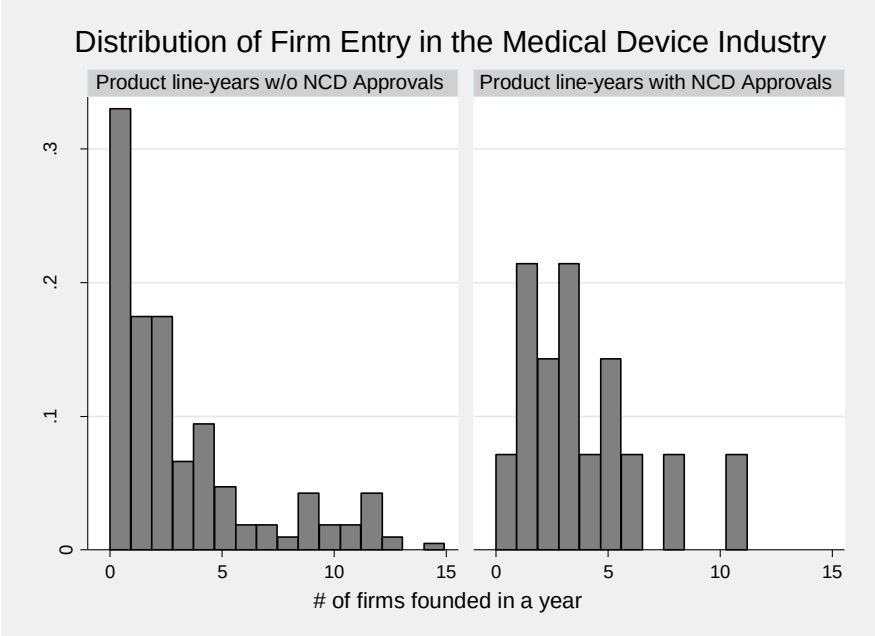
## Figure 1

## Distribution of Firm Entry

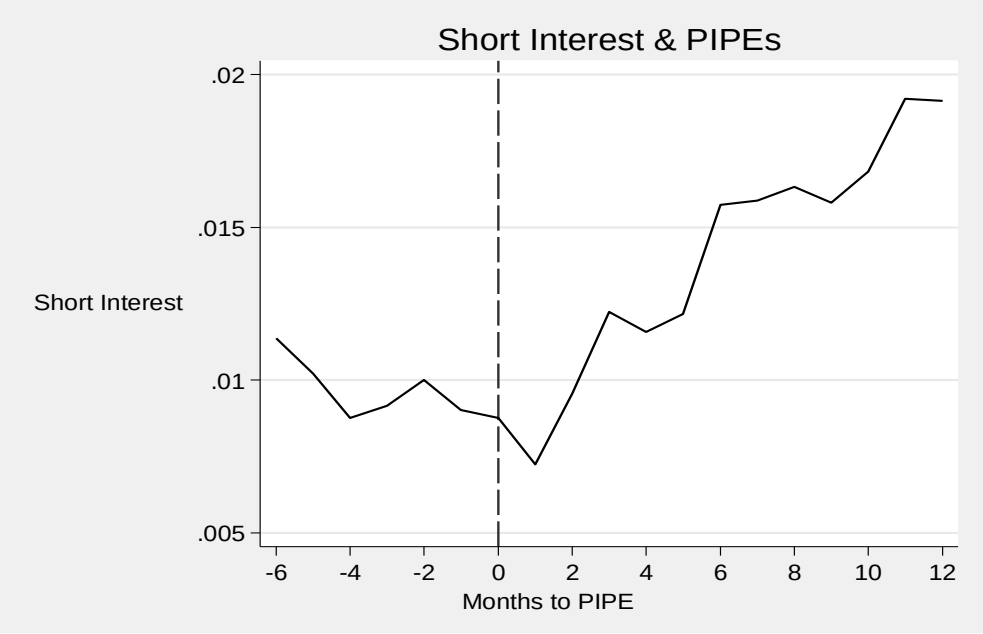
This figure shows the distribution of new founded firms for product-category-years with and without NCD approvals.



## Figure 2

## Short Interest and PIPEs

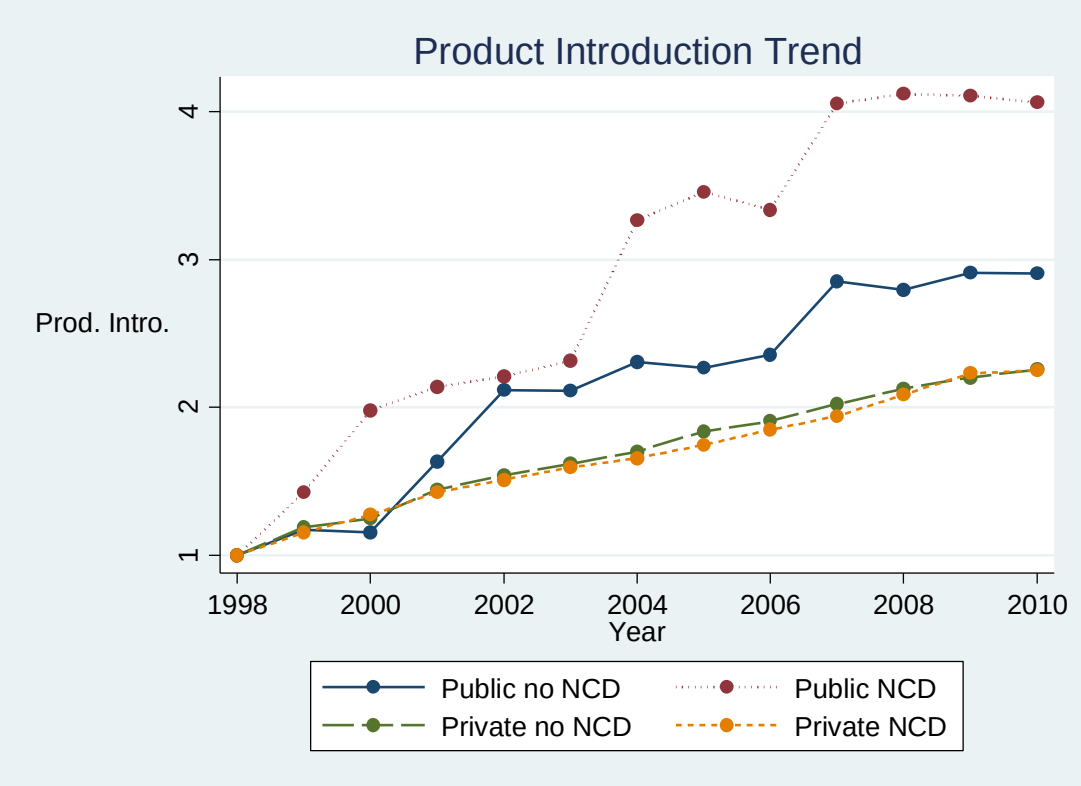
This figure shows the evolution of short interest (shares sold short over total shares outstanding) for months relative to PIPE deals. The figure was constructed using publicly traded companies that satisfy the following criteria: 1-They belong to our sample and issue a PIPE during the sample period; 2-Short interest data is available for in consecutive months in COMPUSTAT; 3-There was no overlap between PIPE deals in the [-6, +12] window around a PIPE; 4-The mean short interest, prior to a PIPE deal, was no higher than 10%.



## Figure 3

## Product Introduction Trends by Subgroups of Public/Private firms with/without NCD Approvals in their Product Category

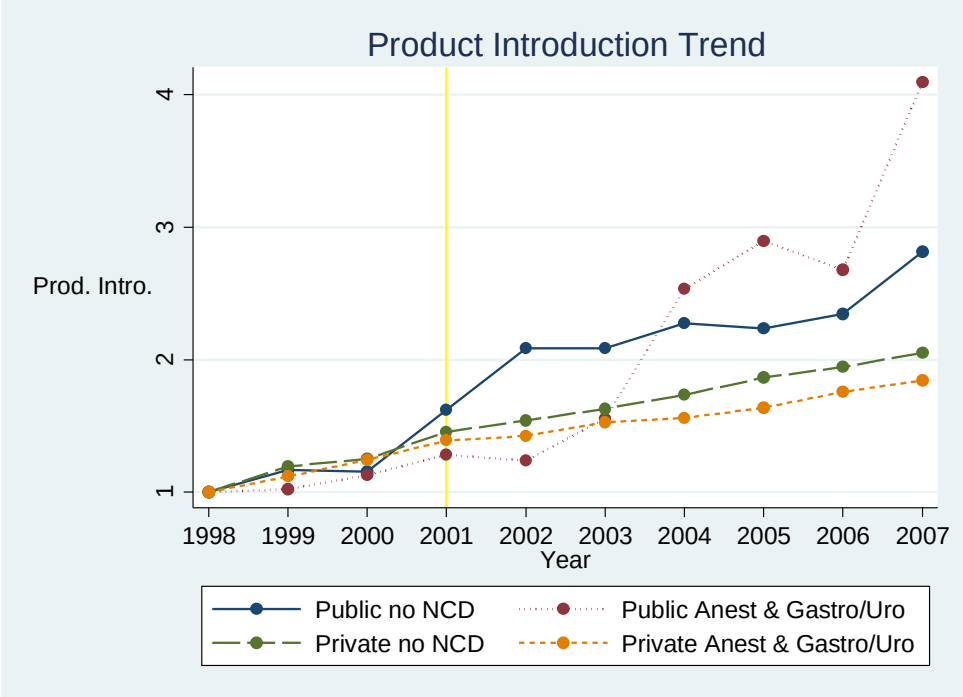
This figure shows product introduction trends for companies that operated through 1998-2010, according to whether their product categories received NCD approvals throughout the sample, and their trading status (public/private). We set the growth rate equal to 1 for all groups in 1998, and for each group-year we add the average within-firm product introduction yearly growth rate to plot each group's product introduction trend over the sample period.



## Figure 4

## Product Introduction Trends for companies in the Anesthesiology and Urology category and companies without NCD approval

This figure shows product introduction trends for companies that operated through 1998-2007, using firms from the Anesthesiology and Urology categories —which received NCD approvals in 2001 — and firms operating in product categories that did not receive a NCD approval during the sample period. We set the growth rate equal to 1 for all groups in 1998, and for each group-year we add the average within-firm product introduction yearly growth rate to plot each group's product introduction trend over the sample period.



## Table 1

## National Coverage Decision Approvals and Extensions for 1998-2010

Panel A summarizes the 17 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 some 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. Column VII shows the review process under which manufacturers need to submit their applications to get FDA approval on each device. Panel B shows the product categories that did not receive a 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 a 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%, and **5%.

### Panel A

| 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 |
| Physical Medicine (PM) | Neuromuscular Electrical Stimulation (NMES) | 2002 | | | | 510K |
| Physical Medicine (PM) | Mobility Assistive Equipment (MAE) | 2005 | 2007 | | | 510K |

**Panel B**

| FDA Device Classification with no NCD Approval/Extension during the sample period: 1998-2010 |
|---|
| Clinical Chemistry (CH) |
| Dental (DE) |
| Hematology (HE) |
| Inmunology (IM) |
| Microbiology (MI) |
| Obstetrics/Gynecology (OB) |
| Ophthalmic (OP) |
| Orthopedic (OR) |
| Pathology (PA) |
| Radiology (RA) |
| Surgery (SU) |
| Toxicology (TX) |

## Panel C

| Event Window | CAR |
|---|---|
| -90, +90 | 21%** |
| -90, +60 | 15.3%* |
| -60, +60 | 11.8%* |
| -10, +10 | 2.6% |

## 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 0; if it does, it takes the transaction amount. *External Financing Transaction* takes a value of 0 if a firm did not obtain external financing in a year, and 1 if it obtained external financing. The variable *Private* is a dummy variable which takes a value of 0 if a company was publicly listed in a year, and 1 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 of *medium* risk. *Products per year* (PMA) is the number of FDA approved products to a firm in a year, which underwent Pre Market Approval (i.e., high risk 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. The variable *NCD Approval* takes a value of 1 if a firm operates in product category that received a NCD approval, for the NCD year itself and the next 3 years, and 0 otherwise.

| Variable | Mean | Pctile 50 | sd | N |
|---|---|---|---|---|
| **Ext. Fin. Amount (US$ million)** | 0.65 | 0.0 | 5.7 | 19105 |
| **Ext. Fin. Transaction** | 0.03 | 0.0 | 0.2 | 19105 |
| **Private** | 0.93 | 1.0 | 0.3 | 19105 |
| **Products per year** | 0.61 | 0.0 | 3.5 | 19105 |
| **Products per year (510 k)** | 0.28 | 0.0 | 0.8 | 19105 |
| **Products per year (PMA)** | 0.33 | 0.0 | 3.4 | 19105 |
| **Age** | 16.55 | 12.0 | 17.5 | 19105 |
| **Sales (US$ million)** | 13.27 | 2.7 | 30.6 | 19105 |
| **Sales/Employee (US$ million)** | 0.16 | 0.12 | 0.21 | 19105 |
| **Products per year/Employee** | 0.03 | 0.0 | 0.1 | 19105 |
| **NCD Approval** | 0.32 | 0.0 | 0.7 | 19105 |

## 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. The external financing transactions of privately held firms include Private Equity (Growth Capital), Initial Public Offerings (IPO), Venture Capital and Bank Loans. The external financing transactions of publicly traded firms include Fixed Income Offerings, Seasoned Equity Offerings (SEO), Private Equity (Private Investments in Public Equity — PIPE) and Bank Loans.

**Panel A: Transaction Types and Values for Private firms (17812 firm-year obs; 1708 firms)**

| Transaction Type | Number of Transactions (#) | % of Deals | Average Transaction Value (US$ Million) |
|---|---|---|---|
| Growth Capital/ Private Equity | 101 | 22% | 16.2 |
| IPO | 22 | 5% | 56.7 |
| Venture Capital | 305 | 68% | 14.1 |
| Bank Loan | 21 | 5% | 36.3 |
| Total | 449 | | |

**Panel B: Transaction Types and Values for Public firms (1293 firm-year obs; 118 firms)**

| Transaction Type | Number of Transactions (#) | % of Deals | Average Transaction Value (US$ Million) |
|---|---|---|---|
| Fixed Income Offering | 5 | 2% | 49.6 |
| Seasoned Equity Offering | 37 | 16% | 53.7 |
| Private Equity (PIPE) | 148 | 65% | 12.4 |
| Bank Loan | 36 | 16% | 21.7 |
| Total | 226 | | |

## Table 4

## Univariate Analysis

Panel A shows the differences in variable means for publicly traded and private firms for the main sample. Panels B and C compare the public firms with two subsamples of matched observations. To construct the first subsample we only consider those publicly traded firms that operate during the whole sample period (i.e., 13 years). Then, we match them to an equal number of private firms that also operate for all 13 years, according to sales, sales per employee, and their 1998 characteristics: age, number of products introduced both in the 510k and PMA categories, and products introduced per employee. To construct the second matched sample we matched publicly traded firm-years to privately held firm-years on products per year (both 510k and PMA), age, sales, sales per employee and products introduced per employee using propensity score matching. This sampling procedure maximizes the accuracy of the match. Significant at: *10%, **5% and ***1%.

**Panel A: Full Sample**

| Variable | Public (N=1393) | Private (N=17812) | Difference (Public-Private) |
|---|---|---|---|
| **Ext. Fin.Amount (US$ million)** | 4.54 | 0.37 | 4.18*** |
| **Ext. Fin. Transaction** | 0.18 | 0.02 | 0.16*** |
| **Products per year (510 k)** | 0.33 | 0.28 | 0.05** |
| **Products per year (PMA)** | 3.09 | 0.13 | 2.96*** |
| **Age** | 17.32 | 16.49 | 0.83 |
| **Sales (US$ million)** | 34.60 | 11.70 | 22.9*** |
| **Products per year/Employee** | 0.32 | 0.30 | 0.02 |
| **Sales/Employee (US$ million)** | 0.20 | 0.16 | 0.04*** |

**Panel B: Matched Sample, suitable for within firm analysis**

| Variable | Public (N=780) | Private (N=780) | Difference (Public-Private) |
|---|---|---|---|
| **Ext. Fin.Amount (US$ million)** | 1.47 | 0.17 | 1.3*** |
| **Ext. Fin. Transaction** | 0.13 | 0.004 | 0.13*** |
| **Products per year (510 k)** | 0.20 | 0.19 | 0.01 |
| **Products per year (PMA)** | 0.37 | 0.01 | 0.36*** |
| **Age** | 18.98 | 19.08 | -0.10 |
| **Sales (US$ million)** | 15.60 | 17.90 | -2.3* |
| **Products per year/Employee** | 0.02 | 0.01 | 0.01*** |
| **Sales/Employee (US$ million)** | 0.20 | 0.19 | 0.01 |

**Panel C: Matched Sample, maximum accuracy**

| Variable | Public (N=1162) | Private (N=1162) | Difference (Public-Private) |
|---|---|---|---|
| **Ext. Fin.Amount (US$ million)** | 3.70 | 0.79 | 2.91*** |
| **Ext. Fin. Transaction** | 0.17 | 0.03 | 0.14*** |
| **Products per year (510 k)** | 0.30 | 0.31 | -0.01 |
| **Products per year (PMA)** | 0.60 | 0.55 | 0.05 |
| **Age** | 17.3 | 18.0 | -0.7 |
| **Sales (US$ million)** | 25.6 | 25.7 | -0.1 |
| **Products per year/Employee** | 0.02 | 0.02 | 0.00 |
| **Sales/Employee (US$ million)** | 0.19 | 0.21 | -0.02 |

## Table 5

## Private and Public External Financing Sensitivity to Investment Opportunities

This table presents 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. Columns I and II present the results using the full sample; columns III and IV present the results for the sample matched on initial observations; columns V and VI present the results for the sample matched on firm-year observations; and column VII presents the results of non-lineal estimations (Tobit in Panel A and Probit in Panel B) using the full sample. 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. Significant at: *10%, **5% and ***1%. Standard errors are adjusted for heteroscedasticity and clusters at the product category level.

| **Panel A: Ext. Fin. Amount** | Full Sample | | Sample Matched on Initial Observation | | Sample Matched on Firm-year Observations | | Tobit |
|---|---|---|---|---|---|---|---|
| **Variable** | **Log(Ext. Fin.Amount)** | **Log(Ext. Fin.Amount)** | **Log(Ext. Fin.Amount)** | **Log(Ext. Fin.Amount)** | **Log(Ext. Fin.Amount)** | **Log(Ext. Fin.Amount)** | **Log(Ext. Fin.Amount)** |
| **Private** | -0.5823** | -0.5875** | | | -1.3320 | -1.3451 | -4.1869*** |
| | (0.2589) | (0.2621) | | | (0.8746) | (0.8829) | (0.4454) |
| **NCD Approval** | 0.1931*** | 0.1904*** | 0.1417*** | 0.1629* | 0.1433*** | 0.2216*** | 2.5091*** |
| | (0.0233) | (0.0247) | (0.0261) | (0.0781) | (0.0281) | (0.0670) | (0.3840) |
| **Private*(NCD approval)** | -0.1916*** | -0.1842*** | -0.1781*** | -0.1687*** | -0.1013* | -0.1165** | -1.2628*** |
| | (0.0235) | (0.0246) | (0.0142) | (0.0289) | (0.0484) | (0.0447) | (0.3786) |
| **Controls** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Controls*(NCD approval)** | No | Yes | No | Yes | No | Yes | Yes |
| **Firm Fixed Effects** | Yes | Yes | Yes | Yes | Yes | Yes | No |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Product Category Cluster** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **R-squared (within)** | 0.0202 | 0.0207 | 0.0477 | 0.0619 | 0.0388 | 0.0412 | 0.098 |
| **N** | 19105 | 19105 | 1560 | 1560 | 2324 | 2324 | 19105 |

| **Panel B: Ext. Fin. Transaction** | Full Sample | | Sample Matched on Initial Observation | | Sample Matched on Firm-year Observations | | Probit |
|---|---|---|---|---|---|---|---|
| **Variable** | **Ext. Fin. Transaction** | **Ext. Fin. Transaction** | **Ext. Fin. Transaction** | **Ext. Fin. Transaction** | **Ext. Fin. Transaction** | **Ext. Fin. Transaction** | **Ext. Fin. Transaction** |
| **Private** | -0.1342 | -0.1363 | | | -0.2450 | -0.2463 | -0.8991*** |
| | (0.1285) | (0.1307) | | | (0.2691) | (0.2702) | (0.1105) |
| **NCD Approval** | 0.0633*** | 0.0619*** | 0.0455*** | 0.0517 | 0.0438** | 0.0598 | 0.5979*** |
| | (0.0130) | (0.0173) | (0.0128) | (0.0326) | (0.0167) | (0.0406) | (0.0722) |
| **Private*(NCD approval)** | -0.0627*** | -0.0601*** | -0.0601*** | -0.0560*** | -0.0410** | -0.0461** | -0.3172*** |
| | (0.0131) | (0.0157) | (0.0061) | (0.0121) | (0.0157) | (0.0163) | (0.0740) |
| **Controls** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Controls*(NCD approval)** | No | Yes | No | Yes | No | Yes | Yes |
| **Firm Fixed Effects** | Yes | Yes | Yes | Yes | Yes | Yes | No |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Product Category Cluster** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **R-squared (within)** | 0.0111 | 0.0114 | 0.0300 | 0.0364 | 0.0222 | 0.0233 | 0.133 |
| **N** | 19105 | 19105 | 1560 | 1560 | 2324 | 2324 | 19105 |

## Table 6

## Economic Effects

This table shows the economic effect of NCD approvals for private and public firms. We consider the economic effect of a 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 5. The first and the second effects are obtained from OLS regressions (Table 5, Panels A and B, column I), the third effect is computed from the Tobit specification (Table 5, Panel A, column VII). Significant at: *10%, **5% and ***1%.

**Economic Effect of a NCD approval on External Financing**

| | Private | Public | Difference |
|---|---|---|---|
| **External funds increase (unconditionally) by:** | 0.7% | 19.1%*** | 18.4%*** |
| **Probability of external financing increases by:** | 0.2%* | 6.2%*** | 6%*** |
| **Conditional on having an external financing transaction, external funds increase by:** | 4.4%* | 15.3%*** | 10.9%*** |

## Table 7

## Timing of External Financing

This table presents linear regressions with firm fixed effects, redefining NCD approvals as single-period shocks (e.g., *NCD Approval dummy (t-4)* takes a value of one 4 years prior to a NCD approval, and zero otherwise). In column one, the dependent variable is the logarithm of external financing amount in the years in which external financing was raised and zero otherwise. In column two, the dependent variable is an indicator variable that equals one if the firm raises external capital in a given year and zero otherwise. Significant at: *10%, **5% and ***1%. Standard errors are adjusted for heteroscedasticity and clusters at the product category level.

| Variable | Log(Ext. Fin.Amount) | Ext. Fin. Transaction |
|---|---|---|
| **Private** | -0.5809* | -0.1206 |
| | (0.2853) | (0.1303) |
| **NCD Approval Dummy (t-4)** | 0.0013 | -0.0587 |
| | (0.0969) | (0.0416) |
| **Private*(NCD Approval Dummy (t-4))** | -0.0073 | 0.0541 |
| | (0.0954) | (0.0408) |
| **NCD Approval Dummy (t-3)** | 0.0080 | 0.0362 |
| | (0.0510) | (0.0285) |
| **Private*(NCD Approval Dummy (t-3))** | -0.0128 | -0.0348 |
| | (0.0544) | (0.0314) |
| **NCD Approval Dummy (t-2)** | 0.0670 | 0.0488 |
| | (0.0714) | (0.0345) |
| **Private*(NCD Approval Dummy (t-2))** | -0.0552 | -0.0456 |
| | (0.0744) | (0.0368) |
| **NCD Approval Dummy (t-1)** | 0.1150 | 0.0507 |
| | (0.0686) | (0.0296) |
| **Private*(NCD Approval Dummy (t-1))** | -0.1450** | -0.0609* |
| | (0.0648) | (0.0296) |
| **NCD Approval Dummy (t)** | 0.2885*** | 0.1366*** |
| | (0.0831) | (0.0325) |
| **Private*(NCD Approval Dummy (t))** | -0.2819*** | -0.1328*** |
| | (0.0774) | (0.0325) |
| **NCD Approval Dummy (t+1)** | 0.3059* | 0.1023** |
| | (0.1496) | (0.0477) |
| **Private*(NCD Approval Dummy (t+1))** | -0.3138* | -0.1036* |
| | (0.1635) | (0.0518) |
| **NCD Approval Dummy (t+2)** | 0.3197*** | 0.1233*** |
| | (0.0871) | (0.0376) |
| **Private*(NCD Approval Dummy (t+2))** | -0.3253*** | -0.1242*** |
| | (0.0801) | (0.0347) |
| **NCD Approval Dummy (t+3)** | 0.2180** | 0.0687* |
| | (0.0934) | (0.0391) |
| **Private*(NCD Approval Dummy (t+3))** | -0.2115** | -0.0630 |
| | (0.0856) | (0.0365) |
| **NCD Approval Dummy (t+4)** | 0.0121 | 0.0324 |
| | (0.1087) | (0.0406) |
| **Private*(NCD Approval Dummy (t+4))** | 0.0063 | -0.0243 |
| | (0.1029) | (0.0381) |
| **Firm Fixed Effects** | Yes | Yes |
| **Year Fixed Effects** | Yes | Yes |
| **Product Category Cluster** | Yes | Yes |
| **R-squared (within)** | 0.0178 | 0.0124 |
| **N** | 19105 | 19105 |

## Table 8

### Multinomial Logit Estimation of Transaction Types Driving the Results

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. 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. Significant at: *10%, **5% and ***1%. The changes in probabilities following a 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** | 0.3203 | 0.2720*** | 0.0588 | 0.4074* |
| | (0.3966) | (0.0738) | (0.1530) | (0.2150) |
| **Controls** | Yes | Yes | Yes | Yes |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes |
| **N** | | 17834 | | |
| **Unconditional Probability** | 0.1% | 1.7% | 0.6% | 0.1% |
| **Marginal Effect (NCD Approval)** | 0.00% | 0.09% | 0.02% | 0.00% |
| **Δ Probability following NCD approval** | 0.0% | 5.3% | 2.6% | 0.0% |

**Panel B:Public firms**

**Default Option: No External Financing**

| Variable | Bank Loan | Fixed Income Offerings | PIPE | SEO |
|---|---|---|---|---|
| **NCD Approval** | -0.1402 | -0.7036 | 0.4642*** | 0.0267 |
| | (0.3307) | (1.3338) | (0.1064) | (0.2292) |
| **Controls** | Yes | Yes | Yes | Yes |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes |
| **N** | | 1271 | | |
| **Unconditional Probability** | 2.8% | 0.4% | 11.6% | 2.9% |
| **Marginal Effect (NCD Approval)** | 0.00% | 0.00% | 4.29% | 0.00% |
| **Δ Probability following NCD approval** | -0.1% | 0.0% | 36.8% | 0.0% |

## Table 9

## Multinomial Logit Estimation for Acquisitions

This table presents multinomial logit regressions examining acquisition activity for both privately held (Panel A) and publicly listed companies (Panel B). We examine whether firms are more likely to be acquired or to acquire other firms according to the covariates included in the estimations. The default option for both panels is that the firm is not involved in acquisitions. 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. Significant at: *10%, **5% and ***1%. The changes in probabilities following a NCD approval are shown at the bottom of each panel.

### Panel A: Private firms

**Default Option: No Acquisition Activity**

| Variable | Acquired | Acquiring |
|---|---|---|
| **NCD Approval** | 0.0414 | 0.1809 |
| | (0.1069) | (0.1264) |
| **Controls** | Yes | Yes |
| **Year Fixed Effects** | Yes | Yes |
| **N** | 17938 | |
| **Unconditional Probability** | 1.1% | 0.7% |
| **Marginal Effect (NCD Approval)** | 0.01% | 0.06% |
| **Δ Probability following NCD approval** | 1.19% | 8.86% |

### Panel B: Public firms

**Default Option: No Acquisition Activity**

| Variable | Acquired | Acquiring |
|---|---|---|
| **NCD Approval** | 0.1083 | -0.1843 |
| | (0.2873) | (0.1740) |
| **Controls** | Yes | Yes |
| **Year Fixed Effects** | Yes | Yes |
| **N** | 1271 | |
| **Unconditional Probability** | 1.7% | 6.4% |
| **Marginal Effect (NCD Approval)** | 0.00% | -0.90% |
| **Δ Probability following NCD approval** | 0.16% | -14.10% |

## Table 10

## Product Introduction Count Regressions

This table presents count regressions examining cumulative product introductions from year t to t+x, where x={1,2,3,4}, using a negative binomial regression, as the dependent variable is a count variable with overdispersion (i.e., the variance is higher than the mean). Panels A and D show results using total product introduction as dependent variable; Panel B shows results using product introduction in the 510(k) category as dependent variable; Panel C shows results using product introduction in the PMA category as dependent variable. The controls included are age, logarithm of sales and sales per employee. Significant at: *10%, **5% and ***1%. Standard errors are adjusted for heteroscedasticity and clusters at the product category level. The marginal effects of NCD approvals on product introductions of private and public firms, as well as their differences, are shown at the bottom of Panels A-C.

**Panel A**

| Variable | Prod. Intro. (t-t+1) | Prod. Intro. (t-t+2) | Prod. Intro. (t-t+3) | Prod. Intro. (t-t+4) |
|---|---|---|---|---|
| **Private** | -0.8267*** | -0.8492*** | -0.8465*** | -0.8657*** |
| | (0.1752) | (0.1872) | (0.1902) | (0.1951) |
| **NCD Approval** | 0.3392*** | 0.3391*** | 0.3796*** | 0.3982*** |
| | (0.1054) | (0.1081) | (0.1096) | (0.1098) |
| **Private*(NCD approval)** | -0.3409** | -0.3169** | -0.3369** | -0.3339** |
| | (0.1554) | (0.1611) | (0.1638) | (0.1615) |
| **Controls** | Yes | Yes | Yes | Yes |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes |
| **Product Category Cluster** | Yes | Yes | Yes | Yes |
| **N** | 17299 | 15514 | 13758 | 12035 |
| **NCD Approval Marginal Effect for Private Firms** | 0.00 | 0.02 | 0.05 | 0.11 |
| **NCD Approval Marginal Effect for Public Firms** | 0.17*** | 0.34*** | 0.57*** | 0.78*** |
| **NCD Differential Effect (Public vs.Private)** | 0.17*** | 0.32** | 0.52** | 0.67** |

**Panel B**

| Variable | 510(k) Intro. (t-t+1) | 510(k) Intro. (t-t+2) | 510(k) Intro. (t-t+3) | 510(k) Intro. (t-t+4) |
|---|---|---|---|---|
| **Private** | 0.1676 | 0.1872* | 0.2151* | 0.2228* |
| | (0.1102) | (0.1107) | (0.1117) | (0.1165) |
| **NCD Approval** | 0.1464** | 0.1332** | 0.1503** | 0.1336** |
| | (0.0662) | (0.0668) | (0.0706) | (0.0674) |
| **Private*(NCD approval)** | -0.2419** | -0.2147* | -0.2203* | -0.1839 |
| | (0.1067) | (0.1130) | (0.1234) | (0.1188) |
| **Controls** | Yes | Yes | Yes | Yes |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes |
| **Product Category Cluster** | Yes | Yes | Yes | Yes |
| **N** | 17299 | 15514 | 13758 | 12035 |
| **NCD Approval Marginal Effect for Private Firms** | -0.02 | -0.04 | -0.05 | -0.05 |
| **NCD Approval Marginal Effect for Public Firms** | 0.04*** | 0.07** | 0.12** | 0.14** |
| **NCD Differential Effect (Public vs.Private)** | 0.06*** | 0.11* | 0.17* | 0.19 |

**Panel C**

| Variable | PMA Intro. (t-t+1) | PMA Intro. (t-t+2) | PMA Intro. (t-t+3) | PMA Intro. (t-t+4) |
|---|---|---|---|---|
| **Private** | -1.5927*** | -1.6591*** | -1.6870*** | -1.7106*** |
| | (0.3393) | (0.3518) | (0.3882) | (0.3964) |
| **NCD Approval** | 0.4525*** | 0.4247** | 0.4561*** | 0.4980*** |
| | (0.1679) | (0.1758) | (0.1617) | (0.1600) |
| **Private*(NCD approval)** | -0.3331 | -0.2773 | -0.3436 | -0.3596 |
| | (0.2952) | (0.3216) | (0.3038) | (0.2722) |
| **Controls** | Yes | Yes | Yes | Yes |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes |
| **Product Category Cluster** | Yes | Yes | Yes | Yes |
| **N** | 17299 | 15514 | 13758 | 12035 |
| **NCD Approval Marginal Effect for Private Firms** | 0.04 | 0.08 | 0.11 | 0.15 |
| **NCD Approval Marginal Effect for Public Firms** | 0.12*** | 0.22*** | 0.38*** | 0.54*** |
| **NCD Differential Effect (Public vs.Private)** | 0.08 | 0.14 | 0.29 | 0.39 |

**Panel D**

| Variable | Prod. Intro. (t-t+1) | Prod. Intro. (t-t+2) | Prod. Intro. (t-t+3) | Prod. Intro. (t-t+4) |
|---|---|---|---|---|
| **Private** | -0.7674*** | -0.7941*** | -0.8091*** | -0.8290*** |
| | (0.2180) | (0.2246) | (0.2252) | (0.2339) |
| **NCD Approval** | 0.3508 | 0.3842 | 0.4425 | 0.4913* |
| | (0.2474) | (0.2613) | (0.2780) | (0.2851) |
| **Private*(NCD approval)** | -0.6440*** | -0.6594*** | -0.7202*** | -0.7462*** |
| | (0.2147) | (0.2161) | (0.2141) | (0.2156) |
| **Category Size** | 4.7553*** | 5.0846*** | 5.2945*** | 5.3808*** |
| | (1.5609) | (1.7789) | (1.9851) | (2.0726) |
| **Private*(Category Size)** | -0.0949 | -0.0581 | 0.1115 | 0.1197 |
| | (1.4946) | (1.6824) | (1.9298) | (2.1005) |
| **(NCD approval)** | -1.5161 | -1.7812 | -1.9971 | -2.1196 |
| ***(Category Size)** | (1.0360) | (1.1499) | (1.2818) | (1.3307) |
| **Private*(NCD approval)** | 1.4698 | 1.6284 | 1.7743 | 1.8691 |
| ***(Category Size)** | (0.9577) | (1.0579) | (1.1526) | (1.2089) |
| **Controls** | Yes | Yes | Yes | Yes |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes |
| **Product Category Cluster** | Yes | Yes | Yes | Yes |
| **N** | 17299 | 15514 | 13758 | 12035 |

## Appendix A

### Examples of the PIPE transactions that drive the results

**Deal #: IQTR2387540.** Cardiac Pathways Corp. (Nasdaq: CPWY) announced a private placement of 40,000 shares of Series B convertible preferred stock at a purchase price of $1,000 per share for aggregate gross proceeds of $40 million on May 20, 1999. The financing will be led by new investors BankAmerica Ventures and Morgan Stanley Venture Partners, and Trellis Health Ventures, and other existing investors also participated in the round. Each shares of Series B preferred stock will be convertible into 200 shares of common stock. The holders of Series B will be entitled to receive cumulative dividend at 11% of the purchase price per share per annum and will vote on all matters on as converted to common stock basis. The Series B stock will be redeemable after May 31, 2004 at the request of the majority shareholders and the approval by the company. As a part of the financing, Mark J. Brooks, Managing Director of BA Venture Partners, and M. Fazle Husain, Principal of Morgan Stanley Venture Partners, will join Cardiac Pathways' board of directors. Julia L. Davidson of Cooley Godward LLP and John Bick of Davis Polk and Wardwell acted as legal advisors to Morgan Stanley Venture Partners and BankAmerica Ventures. Chris F. Fennell of Wilson Sonsini Goodrich & Rosati served as the legal advisor to Cardiac Pathways Corp.

**Deal #: IQTR112649608.** CardioComm Solutions Inc. (VSE: CCG) announced a private placement of 646,667 units at a price of CAD 0.15 per unit for gross proceeds of CAD 0.10 million on March 29, 1999. Each unit consists of one common share of the company and one non-transferable share purchase warrant exercisable for a period of two years. Each warrant entitles the holder to purchase one further common share of the company at a price of CAD 0.15 during the first year and CAD 0.18 during the second year. The warrants will mature on March 29, 2001.

**Deal #: IQTR7282288.** Criticare Systems, Inc. (NASDAQ-NMS: CXIM) announced a private placement of 1,786,273 shares of common stock at $2.25 per share for gross proceeds of $4.02 million on October 17, 2000. The round included participation from new investor Oxford Bioscience Partners with an investment $4 million through its funds Oxford Bioscience Partners III, L.P and Mrna Fund L.P. As part of the round Jeff Barnes, General Partner at Oxford, will join company's board of directors.

**Deal #: IQTR7129416.** On December 23, 2003, HealtheTech, Inc. (Nasdaq: HETC) announced that it has closed $11.7 million in financing commitments from current and new investors. The company sold 15,394,737 shares of common stock at a negotiated price of $0.76 per share. The company also issued warrants to purchase approximately 10,776,316 million shares of common stock at an exercise price of $0.76 per share. Kodial Capital was the lead investor in the transaction. Other investors included Sherbrooke Capital Health and Wellness, LP, New England Partners Capital, LP, JDS Capital Management, Inc., CCM Master Qualified Fund, Ltd. and individual investors.

**Deal #: IQTR23440373.** Medwave Inc. (NasdaqSC: MDWV) announced that it has raised $1,154,672 in the first tranche of a private placement of up to approximately $7 million of units on March 20, 2001. The company issued 181,125 units at a price of $6.375 per unit. Each unit consists of one share of common stock and one warrant to purchase one and one-half shares of common stock. The warrants become exercisable six months after the date of issuance at an exercise price of $6.425 per share. Also, included with each unit is a look-back right entitling the investor to receive, for no additional consideration, a number of additional shares if the company's future gross revenue does not meet certain targets.