

# The Effects of Licensing and Equity Financing Cycles on Pharmaceutical Development

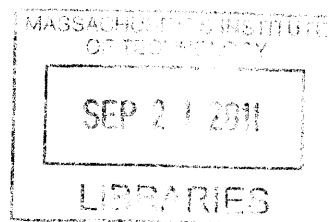
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**ARCHIVES**

SUBMITTED TO THE HARVARD – MIT DIVISION OF HEALTH SCIENCES AND  
TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE  
DEGREE OF  
**MASTER OF SCIENCE IN HEALTH SCIENCES AND TECHNOLOGY**  
AT THE  
**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

September 2011

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# The Effects of Licensing and Equity Financing Cycles on Pharmaceutical Development

By

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Submitted to the Harvard – MIT Division of Health Sciences and Technology  
on September 1, 2011 in Partial Fulfillment of the Requirements for the  
Degree of Master of Science in Health Sciences and Technology

## Abstract

The purpose of this paper is to examine the interactions between licensing status, equity issuance cycles, and drug development success at the small pharmaceutical companies that originate these development projects. Specifically, this paper is aimed at identifying how financing alternatives available to small pharmaceutical companies influence development success and firm behavior. The hypotheses developed and tested in this paper are as follows:

- H1: Pharmaceutical development projects that are licensed are more likely to advance to the next stage in the clinical development process.
- H2: A licensed pharmaceutical development projects' likelihood of advancing to the next stage of the clinical development process will depend on the amount of equity issuance during the period in which the project was licensed.
- H3: Pharmaceutical development projects that are licensed during periods of low equity issuance are more likely to advance to the next stage in the clinical development process than projects that were not licensed or were licensed but not in a low equity issuance period.
- H4: Pharmaceutical development projects that originate at firms that have multiple projects in development at the beginning of a particular clinical trial stage are less likely to advance from phase I to phase II, but more likely to advance in later stages.
- H5: Pharmaceutical development projects that originate at firms that have previously launched a project in the market are more likely to be launched in the market.

The results of a logistic regression analysis suggest that drugs licensed in periods of lowest equity issuance exhibit a higher rate of advancement from phase II to phase III. The relationship between advancement and amount of equity issuance at the time of licensing suggests that the lower the equity issuance in the licensing period the more likely the drug will advance. These results point to the possible existence of a "lemons" phenomenon in the market for pharmaceutical development projects. However, a different interpretation of the results suggests that large pharmaceutical company licensees are superior evaluators of quality and are perhaps more selective and opportunistically license higher quality drugs when equity issuance is low and licensors have no other financing options. Both interpretations point to the issue of information asymmetry as a central theme to this work.

*Dedicated...*

*...to my siblings Sara, Kevin, and Daniel. I admire, appreciate, and love them more than they know.*

*...to my parents. Without their love, support, and encouragement I would not be where I am today.*

## **Acknowledgements**

I would like to thank the following people:

Fiona Murray for her direction and guidance throughout this project.

Jonathan Fleming for his feedback on this paper, for his mentoring over the past few years, and for reminding me to “always stare reality in the face.”

Daniel Liebeskind at Barclays Capital for his input on data analysis.

Alan Braly for his encouragement throughout this project and, most importantly, for drinking a beer with me when no one else would.

All of my BEP colleagues for making the past three years an invaluable, enlightening, and enjoyable experience.

## Table of Contents

<b>I</b>	<b>Introduction</b>	<b>7</b>
<b>II</b>	<b>Background on Pharmaceutical Development and Licensing</b>	<b>8</b>
II.1	Pharmaceutical Development	8
II.2	Licensing in the Pharmaceutical Industry	12
II.3	Financing Alternatives	14
<b>III</b>	<b>Theory</b>	<b>14</b>
III.1	Licensing as a Sign of Project Quality	15
III.2	Information Asymmetry	15
III.3	Access to Capital Markets and Financing Decisions	16
III.4	Internal Capital Markets and Managerial Incentives	17
III.5	Validation From Previous Product Launch	17
<b>IV</b>	<b>Hypotheses</b>	<b>18</b>
IV.1	Effect of Licensing Status	18
IV.2	Effect of Equity Issuance at Time of First License	18
IV.3	Effect of First License in a Low Equity Issuance Period	19
IV.4	Effect of Simultaneous Development Projects at an Originator	19
IV.5	Effect of Previously Launched Projects at an Originator	20
<b>V</b>	<b>Data and Methods</b>	<b>20</b>
V.1	Description of datasets	20
V.2	Model	22
<b>VI</b>	<b>Results</b>	<b>25</b>
VI.1	Review of Hypotheses	25
VI.2	Effect of Control Variables	27
<b>VII</b>	<b>Discussion</b>	<b>27</b>
VII.1	Information Asymmetry and “Lemons”	27
VII.2	Limitations	28
<b>VIII</b>	<b>References</b>	<b>30</b>
<b>IX</b>	<b>Figures</b>	<b>31</b>

## Statement on Conflict of Interest

This work was self-funded and there are no apparent conflicts of interest in this study.

# **I Introduction**

Drug development is the innovation engine of the pharmaceutical industry. As more is learned about disease, new approaches are developed and investigated for targeting biological mechanisms in order to create safer and more effective drugs. Understanding the factors that affect drug development is critical for efficient development in the face of regulatory pressure, uncertain market conditions, low supply of capital, and changing technology.

The industry has experienced a large increase in the number of license agreements in connection with drug development over the last several decades. These license agreements have become an important source of financing for small firms and a vital source of innovation for larger pharmaceutical companies.

The purpose of this paper is to examine the interactions between licensing status, equity issuance cycles, and drug development success at the small pharmaceutical companies that originate these development projects. Specifically, this paper is aimed at identifying how financing alternatives available to small pharmaceutical companies influence development success and firm behavior. The hypotheses developed and tested later in this paper are as follows:

- H1: Pharmaceutical development projects that are licensed are more likely to advance to the next stage in the clinical development process.
- H2: A licensed pharmaceutical development projects' likelihood of advancing to the next stage of the clinical development process will depend on the amount of equity issuance during the period in which the project was licensed.
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H4: Pharmaceutical development projects that originate at firms that have multiple projects in development at the beginning of a particular clinical trial stage are less likely to advance from phase I to phase II, but more likely to advance in later stages.

H5: Pharmaceutical development projects that originate at firms that have previously launched a project in the market are more likely to be launched in the market.

The paper proceeds in section II with a background on the drug development process in the U.S. and licensing agreements in the pharmaceutical industry. Theories about the managerial incentives, information asymmetry, and financing strategy in relation to drug development are reviewed in section III. Hypotheses about these relationships are formed in section IV and the methods utilized to test the hypotheses are developed in section V. The results and discussion are presented in sections VI and VII, respectively.

## **II Background on Pharmaceutical Development and Licensing**

### **II.1 Pharmaceutical Development**

Drug development is a highly regulated and structured process that often takes many years and costs upwards of several hundred million to billions of dollars for a single approved pharmaceutical compound. The process begins with drug discovery and progresses through preclinical testing, clinical development, regulatory review and approval, and finally market launch. The focus of this paper is on drugs that originate from US companies. Therefore, the description of the process below is based on the U.S. Food and Drug Administration's regulations. However, the process is similar in most developed countries.

#### **Drug Discovery**

Drug discovery is the process by which chemical or biologic compounds are screened for potential activity at a therapeutic target. Drug discovery can be divided into two basic approaches: compound-centered and target-centered. The compound-centered strategy involves identifying compounds that



display physiological activity and then developing them for a specific therapeutic area or indication.

Many of the drugs developed through this approach are naturally occurring compounds, or synthetic compounds that either mimic natural compounds or are analogues of human ligands.

The target-centered strategy starts with the identification of a physiological target that is known (or hypothesized) to be of significance in a disease process. One or several of the following methods may then be used to identify drugs that could potentially interact with the target: high-throughput screening, combinatorial chemistry, structure-based design, in-silico modeling, computer algorithms, and vast drug libraries.

The drug discovery phase may involve thousands of candidates while only a few may be selected to proceed to lead optimization. Lead optimization is the process of screening and refining for toxicology and pharmacokinetics. Lead optimization will typically involve testing with in vitro assays as well as animal models.

### **Preclinical Development**

The preclinical stage of drug development refers to the use of animal models of the disease to test for physiologic activity of the drug candidate and pharmacodynamics, as well as to further refine pharmacokinetics, drug distribution, and metabolism.

The distinction between drug discovery and preclinical is not universal. Some may describe everything prior to clinical development as the preclinical stage, while others may uniquely define drug discovery, lead optimization, and preclinical development as separate stages. More important than understanding the semantics is to understand that it is often very difficult to obtain data on drug candidates before they proceed to clinical development. Even though many of the practices in drug discovery and preclinical development are regulated, companies are not required to make this information public and have little incentive to do so in the preclinical stage.

## **Investigational New Drug Application**

Prior to administering a xenobiotic compound to a human in a clinical trial, the sponsor of the trial must apply to the U.S. Food and Drug Administration (FDA) by submitting an Investigational New Drug Application (IND). Among other clinical and scientific data, the IND will contain background information on the drug candidate, the results of preclinical testing, and the protocol to be used for the administration to humans. The IND is reviewed by the FDA for medical, chemical, pharmacological, toxicological, and statistical soundness. If no deficiencies are noted, the IND is approved and the sponsor is allowed to proceed with clinical development.

## **Clinical Development**

Once an IND is approved, the drug candidate can proceed into the clinical development phases, which is notably distinct in that the testing takes place using human subjects. The regulatory and logistic aspects of clinical trials are complex. The focus here will be on the purpose and differences of the sequential phases of clinical development.

Clinical trials are carefully designed studies with prospective clinical endpoints. At the end of each phase, the sponsor would review (with regulatory oversight) the results of the trial and its success in meeting the endpoints to determine if the drug candidate should advance to the next phase. However, just because a drug candidate was successful in a particular phase does not mean that it will advance further in the development process. Changing market conditions, competitor dynamics, lack of resources, or a change in strategic direction are just some of the reasons why a company may choose not to advance a drug candidate.

### Phase I

The purpose of a phase I trial is primarily to establish that the drug candidate is safe and tolerable. The maximum tolerated dose, pharmacokinetic profile, toxicity, and adverse effects are studied in a relatively small number of healthy subjects, usually less than 100.

## Phase II

Phase II trials can involve several hundred human subjects and have multiple objectives. Phase II studies usually consist of phase IIa and phase IIb trials. A phase IIa trial is essentially a dose-ranging study in diseased subjects where the desired outcomes are preliminary evidence of efficacy, effective range of doses, and the optimum dose and dosing frequency. The pharmacodynamic profile of the drug candidate is also investigated in a phase IIa trial. A phase IIb trial seeks to establish a definitive dose-response relationship and proof of efficacy in diseased patients. As in phase I trials, safety is monitored so that any less common adverse effects might be detected with the larger number of subjects. Phase II trials are usually blinded, placebo-controlled, and restricted to a well-defined study cohort.

## Phase III

Phase III trials are conducted with a more general population of diseased subjects. The purpose is to confirm efficacy in a large enough population that the results could reasonably be extrapolated to the general population of patients who would receive the drug. Phase III trials also establish the complete safety profile and serve as the basis for meeting regulatory guidelines and labeling requirements. Phase III trials can involve thousands of patients with multiple treatment arms, and they are either placebo-controlled or tested against a therapy with demonstrated efficacy. Sponsors are required to complete two pivotal phase III clinical trials before submitting for regulatory approval.

## **New Drug Application & FDA Review**

Following the successful completion of phase III, a sponsor can submit a New Drug Application (NDA) to the FDA for review. The NDA contains all of the data obtained during development of the drug candidate including information on manufacturing and quality control, package and labeling, nonclinical pharmacology and toxicology, human pharmacokinetics, metabolism and bioavailability, clinical data, patent information, etc. Depending on the proposed indication of the drug candidate, a review team at the FDA is assigned to the NDA. Typical review times are between 6 months and a year. After reviewing the NDA, the FDA will make a determination of approved, not approved, or approvable. A response of

“not approved” will be accompanied by a list of deficiencies and suggestions. However, a “not approved” response usually means that new studies must be performed to correct the deficiencies and these NDAs are typically abandoned. The drug candidate could still be developed for another indication by undertaking new clinical trials to show efficacy for a different disease. An “approvable” response means that some deficiencies were noted and the FDA requires more data before making a determination.

### **Market Launch**

After receiving FDA approval the sponsor of the drug, or another entity that has marketing rights, may begin manufacturing and selling the drug as a FDA-approved pharmaceutical. This requires manufacturing, distribution, a sales force, marketing, and of course a demand for the drug to be used in a clinical setting.

### **Cost of Development**

The total cost of drug development is a disputed figure. Several studies have been conducted that place the average total capitalized cost per approved drug in excess of a billion dollars. The mean cash outlay is roughly \$300 million for the clinical period of drug development (DiMasi, Hansen, and Grabowski 2003). Large established pharmaceutical firms can use cash on hand or cash flows from product revenues to finance drug development. Small firms, however, will require other financing options.

## **II.2 Licensing in the Pharmaceutical Industry**

### **Licenses**

A license agreement is a form of technology transfer in which the owner or rights holder of intellectual property grants its use to the licensee. In the pharmaceutical industry, licensing of development stage pharmaceutical technology takes place for many reasons. Not the least of which is the financial compensation the licensor receives as a part of the deal.

As the cost of development increases in the later stages of clinical development, smaller companies often cannot fund the development with resources on hand. Licensing allows the formation of strategic

alliances by formalizing the terms of the agreement. In addition to providing financial compensation to the licensor, alliance partners can often provide resources to aid in the development (financial, human capital, expertise, etc.), manufacturing capabilities, or commercial capabilities such as marketing and distribution (Mendes 2005).

Licensees seek access to these pharmaceutical development projects as an alternative to investing in their internal R&D capabilities. A licensee may be interested in exploiting the technology in a different field of application as the licensor. A licensee may also be looking to diversify their investments in drug development and see a strategic alliance or in-license of a project as an appropriate way to manage their risk.

### **Strategic Alliances**

In the pharmaceutical industry, strategic alliances generally come in two varieties: co-development agreements and co-marketing agreements. Under a co-development agreement a licensor grants to the alliance partner rights to exploit the technology. Together the licensor and licensee jointly develop the technology. Typically, a licensee will pay the licensor an upfront fee followed by milestone payments and royalties. The milestone payments are usually payable upon successful completion of clinical trials, regulatory filing, approval, product launch, or some combination of these. This arrangement gives the licensee access to the technology at a reasonable upfront cost, aligns the incentives for successful development of the drug, and gives the licensor partial benefits of the upside. The licensor can contribute to the further development of the pharmaceutical and influence the likelihood of success. Both parties will capture value as the project successfully advances through the development process.

Co-marketing agreements are similar to co-development agreements. The licensor and licensee can both contribute to the marketing and sale of a developed pharmaceutical. The two parties may have access to different geographic areas or provide complementary functions, i.e. manufacturing, distribution, sales, or

other commercial roles. Again, both parties contribute and create a larger potential upside (Mendes 2005).

A license agreement is necessary for both types of strategic alliances to establish the terms and to allow both parties to exploit the intellectual property and benefit from the arrangement.

## **II.3 Financing Alternatives**

A pharmaceutical firm may have several options for financing its pharmaceutical development projects. Large established firms with significant revenues can fund R&D projects with cash flows from marketed projects. Also, these cash flow positive firms with established financial history can more easily access capital markets should they need to.

Small firms, on the other hand, are more constrained in their financing options. Private companies, primarily financed by venture capital or private equity, may only have enough cash to finance phase I and small phase II clinical trials. Therefore, these firms' ability to successfully demonstrate value early in the development process is crucial to their ability to raise follow-on financing. The investors in these companies will look to exit their investments through initial public offering in the equity markets or acquisition by another pharmaceutical company. Similarly, small publicly traded pharmaceutical companies often have no significant revenue from product sales and they may have cash reserves that only allow them to execute on a small number of early phase clinical trials. Both private and small public firms will seek licensing agreements or strategic alliances in order support their continued operations and development projects.

## **III Theory**

Due to the structure and regulation of pharmaceutical development, the industry has been a testing ground for economists and other academics for decades. There is a plethora of literature written using the

pharmaceutical industry to test many theories related to the topic of this paper. A few of these papers are presented below to establish a foundation for the creation of the model defined below.

### **III.1 Licensing as a Sign of Project Quality**

It has been demonstrated that alliances send a positive signal to capital markets and result in higher valuations of the licensor after these alliances have been formed (Nicholson, Danzon, and McCullough 2005). The large pharmaceutical company licensees in these alliances validate the development projects simply by forming the alliance.

Extrapolating this concept to include all license agreements on a drug, any license agreement on a pharmaceutical development project can be considered a signal of quality. Licensees will carefully evaluate a project prior to a license agreement. These licensees may have a greater ability to judge the quality and value of a project than investors in public markets or venture capital. Therefore, it is assumed that any license on a project is a positive signal of quality.

### **III.2 Information Asymmetry**

There is inherent information asymmetry in drug development. The originator of a development project is in a better position to judge the quality of the project than financial intermediaries and public markets. However, large pharmaceutical companies may be superior evaluators of the quality of a project as evidenced by the positive signal resulting from a license agreement. This information asymmetry can impact firm behavior. An originator will form views on the quality of their own development projects and the firms' incentives will affect how this information is conveyed to investors and potential licensees (Nicholson, Danzon, and McCullough 2005).

Information asymmetry and incentives are especially important for small firms. Small firms may only have a few development projects and the success of these projects will determine the future of the company and its employees. Assuming a company can accurately determine the quality of its development projects, this information will impact the company's behavior. For example, if a firm

determines the quality of a project to be high and therefore its likelihood of success to also be high, the firm will be more likely to continue the development of the project and will seek to finance it in a manner that allows it to capture the most value. On the other hand, if a project's quality is perceived to be low, the firm will be incentivized to monetize the project early by licensing it to another firm.

In reality, a firm cannot determine the quality of a development project with complete certainty.

Therefore, it will seek a strategy that allows it to maximize value and minimize risk. In doing so, the firm may take advantage of the information asymmetry.

### **III.3 Access to Capital Markets and Financing Decisions**

Capital markets will cycle through periods of high and low accessibility as a function of macroeconomic conditions and other industry events. These cycles influence how firms will invest in development projects and how they will choose to finance these projects. These cycles also influence the behavior of other financing intermediaries. Venture capital investors' ability to exit investments depends on the accessibility of capital markets. Larger pharmaceutical companies' ability to issue debt or equity to support an acquisition is also affected by capital market cycles.

When a small firm has a choice in how it finances its development projects, it will seek a strategy that maximizes value and promotes the continued operation and existence of the company. When a firm has access to equity capital markets and the cost of equity is low, it will choose to finance high value projects with equity so that it can capture more value. It will choose to divest low value projects by licensing them to other firms. However, when access to equity markets is limited and the cost of equity is high, a small, capital-constrained firm will be forced to seek suboptimal financing strategies. This means that a firm will license more high quality projects in order to support their development while giving up a portion of the upside.

Other studies have focused on the limited bargaining power of small firms during periods of low equity issuance. They state that lower bargaining power translates to more property rights assigned to the



licensee in a strategic alliance (Lerner, Shane, and Tsai 2003). The less property rights at the originating firm leads to lower success rates in the development process (Higgins 2007). Therefore, these studies conclude that strategic alliances formed during periods of low equity issuance are therefore less successful. However, for the purposes of this paper property rights in the license agreement are not observed and it is assumed that any license on a project is a vote of quality.

### **III.4 Internal Capital Markets and Managerial Incentives**

It has been shown that small-portfolio firms are more likely to advance projects from phase I to phase II but less likely to advance after that. This suggests that managerial incentives influence the decisions to take a project forward in the clinical development phase (Guedj and Scharfstein 2008). A firm with several projects will have a more efficient internal capital market and resources will be diverted from low quality projects to high quality projects. However, if a firm has very few development projects it will be less likely to abandon low quality projects.

### **III.5 Validation From Previous Product Launch**

Because of the effects of information asymmetry and managerial incentives at small firms and the length of time it takes to successfully develop and launch a pharmaceutical, a firm could originate and license several low quality projects before there is a shift in information asymmetry. Firms that originate high quality projects would ultimately be validated once a project is successfully developed and launched in the market. Therefore, it could be expected that projects originating from firms which have originated previously launched projects are of higher quality and should be more likely to advance in the development process. Having previously originated a launched project is regarded as a signal of quality for the firm.

## IV Hypotheses

The following hypotheses follow from the theory section above.

### IV.1 Effect of Licensing Status

Pharmaceutical development projects that are licensed are more likely to advance to the next stage in the clinical development process.

$$H1: P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} \cap \Lambda_{t_0} = 1) > P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} \cap \Lambda_{t_0} = 0)$$

$$\Phi = \begin{cases} 1 & \text{Phase I} \\ 2 & \text{Phase II} \\ 3 & \text{Phase III} \\ 4 & \text{Launch} \end{cases}$$

The subscript  $t_0$  indicates the reference date for each project. The reference date is the earliest date that the project initiated a clinical trial of a given phase. For instance, the earliest date that a particular project started a phase I trial will be its  $t_0$  for the phase I data set. The variable  $\Phi$  indicates the clinical trial phase. The term  $\Phi_{\forall t > t_0} > \Phi_{t_0}$  therefore refers to the advancement of the project to a subsequent phase.

### IV.2 Effect of Equity Issuance at Time of First License

A licensed pharmaceutical development projects' likelihood of advancing to the next stage of the clinical development process will depend on the amount of equity issuance during the period in which the project was licensed.

$$H2: P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} \cap \Lambda_{t_0} = 1) = f(EI(Q_{t_L}))$$

$$EI(Q_{t_L}) = \int_{q_0}^{q_1} \text{Equity Issuance}_{\text{Pharma Index}}(t) dt \mid q_0 < t_L < q_1$$

The  $EI(Q_{t_L})$  function is the amount of equity issuance in the pharmaceutical industry for a given quarter.

### IV.3 Effect of First License in a Low Equity Issuance Period

Pharmaceutical development projects that are licensed during periods of low equity issuance are more likely to advance to the next stage in the clinical development process than projects that were not licensed or were licensed but not in a low equity issuance period.

$$H3: P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} \cap E_{t_L} = 1) > P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} \cap E_{t_L} = 0)$$

$$E_{t_L} = \begin{cases} 1 & EI(Q_{t_L}) < EI_{\text{threshold}} \\ 0 & \text{otherwise} \end{cases}$$

The  $E_{t_L}$  variable is a transform of the equity issuance at the time the project was first licensed from a continuous variable to a binary variable where an arbitrary *threshold* value was used to define a low equity issuance period.

### IV.4 Effect of Simultaneous Development Projects at an Originator

Pharmaceutical development projects that originate at firms that have multiple projects in development at the beginning of a particular clinical trial stage are less likely to advance from phase I to phase II, but more likely to advance in later stages.

$$H4a: P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} = 1 \cap \Gamma_{t_0} = 1) < P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} = 1 \cap \Gamma_{t_0} = 0)$$

$$H4b: P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} > 1 \cap \Gamma_{t_0} = 1) > P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} > 1 \cap \Gamma_{t_0} = 0)$$

$$\Gamma_{i,t_0} = \begin{cases} 1 & \sum_j r_{ij} > 1 \forall r_{ij} | \Phi_{t_0}(r_{ij}) < 4 \\ 0 & \text{otherwise} \end{cases}$$

The  $\Gamma_{i,t_0}$  variable indicates whether there are concurrent development projects at time  $t_0$  at the same originating company  $i$  as project  $r_j$ . The subscript  $i$  indexes a particular company and the subscript  $j$  indexes a particular development project with reference date  $t_0$ .

## IV.5 Effect of Previously Launched Projects at an Originator

Pharmaceutical development projects that originate at firms that have previously launched a project in the market are more likely to be launched in the market.

$$H5: P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} \cap \Gamma_{t_0} = 1) > P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} \cap \Gamma_{t_0} = 0)$$

$$\Pi_{i,t_0} = \begin{cases} 1 & \sum_j r_{ij} > 0 \forall r_{ij} | \Phi_{t_0}(r_{ij}) = 4 \\ 0 & \text{otherwise} \end{cases}$$

## V Data and Methods

### V.1 Description of datasets

The Pharmaprojects database was used to identify all pharmaceutical development projects originating at U.S. companies. The data was separated into sets based on clinical trial phases. Three separate data sets were created for every project that initiated a phase I, phase II, or phase III clinical trial. Phase I/II and phase II/III projects were treated as phase I and phase II projects, respectively. The date of the earliest instance of a clinical trial in the given phase was used as the reference date to obtain the market capitalization value from Factset, a financial markets database. Using market capitalization data, and information from CapitalIQ and Bloomberg, the projects in each of the three clinical trial phase data sets were separated between public and private companies on the reference date. For the public companies, the market capitalization was inflation adjusted to 2011 dollars. A cutoff of an inflation-adjusted \$2 billion market capitalization was used to restrict the analysis to small public companies. This resulted in six unique data sets: a private company subset and a small public company subset for each of the three clinical trial phase data sets. These data sets were further filtered for projects that had recent reference dates but no subsequent clinical trial in a later phase (within 2 years for phases I and II, and three years for phase III) and for projects that were indicated as having been licensed but did not have an associated licensing date. Projects that originated at organizations other than traditional pharmaceutical or

biotechnology companies were also excluded (e.g. not-for-profit organizations or academic institutions). This left a total of 1,738 unique pharmaceutical development projects with 1,117 observations for phase I, 828 observations for phase II, and 371 observations for phase III. Figure 1 displays the summary statistics for the six datasets.

### **Low Equity Issuance Periods**

The  $E_{t_L}$  variable, as previously defined, is a binary variable given the value of 1 to indicate that on the reference date  $t_0$  (the date associated with the earliest trial of a given phase) the project was licensed and also that the license date  $t_L$  occurred in a period of low equity issuance.

Periods of low equity issuance were determined using the Bloomberg United States Pharmaceutical Index (BUSPHRM:IND). All equity issuances from index companies since 1989, the year of the earliest license in the dataset were summed into quarters. These values were inflation adjusted and a moving average for each quarter was taken over the current quarter and the previous three. Then, based on the date of the earliest license on a pharmaceutical project and the amount of averaged equity issuance in that quarter, that project was defined as being licensed in a low equity issuance period or not. This confined the analysis to those licensing characteristics which were only observable on the reference date. The graph of equity issuance and number of first licenses appears in Figure 2.

The threshold value for defining periods of low equity issuance was chosen to be \$1,200 million. This put approximately a third of the equity issuance periods in the low equity issuance category.

The Pharmaprojects database was used to calculate the other regression variables as previously defined.

## V.2 Model

### Logistic Regression Analysis

For each project that started a given phase of clinical trials,  $A_j(\Phi_{t_0})$  was defined as a dependent binary variable that measures advancement of the project to the subsequent phase of development. The variable took the value of 1 if there was a subsequent clinical trial in a later phase, and 0 otherwise.

$$A_j(\Phi_{t_0}) = \begin{cases} 1 & \Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0} \\ 0 & \text{otherwise} \end{cases}$$

Based on the theory and hypotheses, it follows that the probability of advancing to a subsequent stage of clinical trials is a function of the licensing status, the level of equity issuance at the time of the first license, the number of current development projects at the same originating firm, and the number of previously launched projects at the originating firm.

$$P_{Adv} = P(A_j(\Phi_{t_0})) = P(\Phi_{\forall t > t_0} > \Phi_{t_0} | \Phi_{t_0}) = f(\Lambda_{t_0}, E_{t_L}, \Gamma_{i,t_0}, \Pi_{i,t_0})$$

Logistic regression will be employed to investigate the effect of these variables on the probability of advancing to a subsequent phase of clinical development.

Since  $\Lambda_{t_0}$ ,  $EI(Q_{t_L})$ , and  $E_{t_L}$  are related variables, i.e. they are all related to the licensing status, three logistic regression models were used to test H1, H2, and H3 in order to prevent confounding factors.

Testing of H1 simply involves investigating the effect of licensing status at the commencement of a clinical trial phase on the probability of advancement to a subsequent clinical trial.

$$\text{logit}(P_{Adv}) = \alpha + \lambda \Lambda_{t_0} + \gamma \Gamma_{i,t_0} + \pi \Pi_{i,t_0} + \beta \text{ Control Variables}$$

In order to test H2, the datasets were limited to only those projects that were licensed on the reference dates. Then a regression with  $EI(Q_{t_L})$  as an independent continuous variable was performed.

$$\text{logit}(P_{Adv}) = \alpha + \mu EI(Q_{t_L}) + \gamma \Gamma_{i,t_0} + \pi \Pi_{i,t_0} + \beta \text{ Control Variables}$$

The regression model for H3 uses the binary variable  $E_{t_L}$  to indicate that the project was licensed in a low equity issuance period.

$$\text{logit}(P_{Adv}) = \alpha + \varepsilon E_{t_L} + \gamma \Gamma_{i,t_0} + \pi \Pi_{i,t_0} + \beta \text{ Control Variables}$$

H4 and H5 were tested by including  $\Gamma_{i,t_0}$  and  $\Pi_{i,t_0}$  in each of the three models.

### **Controlling for Potential Market Size, Therapeutic Area, Reformulations, and Biologics**

The Pharmaprojects database contained information on potential market size, therapeutic area, drug reformulations, and biologics. Control variables using this information are described below.

#### Market Size

Pharmaprojects assigns Market Size Ratings to each of the projects as follows:

The rating is based on the reported worldwide sales for its primary therapeutic category. The five bands of sales value are as shown:

- |   |                             |
|---|-----------------------------|
| 1 | \$0 - \$500 million         |
| 2 | \$501 - \$2,000 million     |
| 3 | \$2001 - \$5,000 million    |
| 4 | \$5001 - \$10,000 million   |
| 5 | \$10,000 million or greater |

A score of 0 is shown where a market size value is not applicable.

The market size data has been collected from a variety of reputable sources (e.g. analysts, industry reports, and company information) and means are calculated to place each therapeutic classification within a band. The ratings were independently verified and are under constant review.

Dummy variables were defined for the market size ratings combining categories 4 and 5 into *Market Size High* and combining categories 2 and 3 into *Market Size Mid*. An important note on the Market Size Ratings: the rating values read from the Pharmaprojects database are the current ratings on the date the database was accessed and not necessarily the same rating that the project had on the reference date.

## Therapy Codes

The Pharmaprojects database includes primary therapy codes for each project. The broad categories for these therapy codes appear below:

A	Alimentary/Metabolic
B	Blood/clotting
C	Cardiovascular
D	Dermatological
F	Formulations
G	Genitourinary and Sex Hormones
H	Hormones excluding Sex Hormones
I	Immunological
J	Anti-infective
K	Anticancer
M	Musculoskeletal
N	Neurological
P	Antiparasitic
R	Respiratory
S	Sensory
T	Biotechnology
V	Miscellaneous

If a primary therapy code was defined as Formulations or Biotechnology, then the most obvious of the other assigned Therapy Codes was chosen as a replacement for the analysis. *TherCode* was defined as a categorical variable for each project for the regression analysis.

## Reformulation

The Formulation section covers novel reformulations of existing drugs, generally using novel technologies, and also including novel fixed-dose combinations.

Since these are reformulations of existing drugs, the safety and efficacy profiles should be well understood and one would expect that they experience a higher success rate in advancing to subsequent phases.

If the primary therapy code is listed as Formulation, then a *Formulation* dummy variable took a value of 1 and the most prominent or obvious therapy code was then chosen to replace it for the *TherCode* categorical variable described above. Pharmaprojects describes the Formulation category as follows:



## Biologic

The Pharmaprojects database also has a Biotechnology therapy code category. If any therapy code describing a project was the Biotechnology category, then the dummy variable *Biologic* took a value of 1.

The Biotechnology classes on Pharmaprojects cover all drugs involving:

- Recombinant proteins/peptides/vaccines (including biosimilars)
- DNA/RNA-based therapeutics (gene therapies or oligonucleotides)
- Monoclonal antibodies and their conjugates/fusions/derivatives
- Advanced therapeutic cell cultures (e.g. stem cells)

## **VI Results**

The regression results are presented in Figures 3 through 14. Regressions were performed adding new variables in each column. Columns A through E in Figures 3 through 8 show the results using  $\Lambda_{t_0}$ , the licensing status, as an independent variable. Columns F through J use  $E_{t_L}$ , the variable indicating that the project was licensed in a low equity issuance period. Columns B and G add  $\Gamma_{i,t_0}$  the variable indicating simultaneous development projects at the originating firm. Columns C and H add  $\Pi_{i,t_0}$  the variable indicating previously launched projects that originated at the same firm. Columns D and I add the market size control variables and columns E and J add the therapy code control variables.

Figures 9 through 14 show the regression results for licensed projects using  $EI(Q_{t_L})$ , the amount of equity issuance at time of licensing as an independent continuous variable.

### **VI.1 Review of Hypotheses**

#### **Hypothesis 1**

The licensing status of a project  $\Lambda_{t_0}$  is associated with an increased likelihood of advancement to the next phase of clinical trials. In all of the results, the odds ratio for the  $\lambda$  coefficient is greater than 1 and ranges between 1.16 and 3.37. The most significant results for licensing status occur for phase II to phase III advancement probabilities at small public companies (Figure 6 columns A through E) where the p-values

were less than 10%. All other datasets failed to produce significant results. Therefore, H1 cannot be accepted with statistical significance.

### **Hypothesis 2**

The amount of equity issuance at the time of licensing for licensed projects did not produce consistent results across the datasets. For phase II to phase III advancement at private companies (Figure 11) and phase III to launch advancement at public companies (Figure 14) the results were significant and in the predicted direction as indicated by the negative coefficient. For these data sets, an increase in the amount of equity issued during the period in which the project was first licensed results in a decrease in likelihood of advancement to the next stage. Hypothesis 2 can be accepted with statistical significance but limited to these datasets.

### **Hypothesis 3**

A project licensed in a low equity issuance period also experiences an increased likelihood of advancement for most of the datasets. The most significant results were for the phase II to phase III advancement probabilities at both private and small public companies (Figures 5 and 6 columns F through J). The advancement from phase III to launch at small public companies also produced statistically significant results (Figure 8 columns F through J). Hypothesis 3 can be accepted with statistical significance for phase II to phase III advancements and phase III to launch at small public companies.

### **Hypothesis 4**

The existence of concurrent development projects at a firm did not appear to significantly influence the probability of advancement. In the single dataset where the  $\Gamma_{i,t_0}$  variable approached statistical significance (Figure 5), the coefficient indicated that the effect was in the opposite direction predicted in hypothesis 4. Therefore, hypothesis 4 is rejected.

## **Hypothesis 5**

Previously launched projects from the originating firm did not have an effect in the earlier stages of clinical development. However, for phase III to launch advancement at small public companies the effect was statistically significant with an odds ratio ranging between 2.22 and 2.62. Hypothesis 5 is accepted for the phase III to launch for the small public companies dataset.

## **VI.2 Effect of Control Variables**

In general, the inclusion of the variable to control for market size and therapy code did not seem to greatly impact the results. Furthermore, since Pharmaprojects uses the therapy code in assigning the potential market size, there could be a confounding factor when including these variables in the regression analysis.

## **VII Discussion**

### **VII.1 Information Asymmetry and “Lemons”**

One interesting result of the regression analysis is that a license alone does not appear to have a great effect on the likelihood of advancement. However, the drugs that were licensed in the periods of lowest equity issuance do exhibit a higher rate of advancement from phase II to phase III. The relationship between advancement and amount of equity issuance during the licensing period as shown in figures 11 and 14 would suggest that the lower the equity issuance in the licensing period the more likely the drug will advance. These results point to the possible existence of a “lemons” phenomenon in the market for pharmaceutical development projects (Pisano 1997). When these small firms have the ability to finance their higher quality projects through non-licensing means, they are more likely to license their lower quality projects. When licensing is the only option to finance development, they license out both their high and low quality projects.

There is, however, a different interpretation of these results. Since large pharmaceutical company licensees are superior evaluators of quality, perhaps they are more selective and opportunistically license

higher quality of drugs in a buyers' markets, i.e. when equity issuance is low and licensors have no other option for financing development. Both interpretations point to the issue of information asymmetry as a central theme to this work.

Also worth noting are the relative significance of the phase II to phase III advancement results. Generally, the regression results for these datasets produced statistically significant results and the coefficients were of greater magnitude. This could be related to the characteristics of phase II trials. Phase II clinical trials are usually the first studies in which drug candidates are given to actual diseased or afflicted subjects. Efficacy is observed for the first time in human beings. Phase II trials also tend to exhibit the highest failure rates relative to the other phases. If successful, the results of these trials provide the first proof of concept for the drug.

It may be the case that the information asymmetry is highest going into a phase II trial. Also, the ability to determine the quality of a project may not be a linear function of the absolute quality of the project. Drugs with the highest quality may be readily identified as high quality and easily licensed. As the absolute quality of a drug decreases even slightly, it may become very difficult to observe the quality of the drug. Therefore, drugs that are of lower quality on an absolute scale but have relatively different quality may be perceived as having similar quality. Licensors may be more likely to wait for a correction of the information asymmetry following the phase II results before pursuing a license agreement.

## **VII.2 Limitations**

There are several limitations to this research. The first limitation is that the date of the first license is used as the reference date for licensing. It is possible that license agreements are terminated or renegotiated. Terminated projects may be re-licensed at later dates. Another potential criticism is that the terms and property rights assigned in the license agreements are not observable in the Pharmaprojects database. It is possible for a drug to be non-exclusively licensed and the relative property rights assigned in each license could make one license agreement a better signal of quality than another. Without the ability to observe

the details of the license agreement it is difficult to ascertain which license agreement is most relevant for this study if a single project has multiple license agreements.

License agreements may also result indirectly from unrelated corporate action, e.g. an acquired company or subsidiary may license an entire portfolio of projects to the acquirer or parent organization. Licenses under these types of situations may create data points that are not appropriate or relevant to this study.

Over the course of the sample period there have been many changes in the pharmaceutical industry that are not controlled for in the analysis. The impact of regulatory changes could impact development strategy, capital markets, likelihood of success, cost, and value of a project. Scientific advancements and increased biological/physiological knowledge have led to significant changes in drug discovery and development. Additionally, over the course of the sample period there have been changes in the structure of licensing deals (e.g. milestone payments, royalties, assignment of property rights between licensor and licensee, etc.) that may affect the analysis.

Perhaps the most important changes over this period are the rapid rise in clinical trial costs (DiMasi et al. 2007 and 2003) and the increased risk of regulatory rejection. The rise in clinical trial costs has accelerated and quickly outgrown the amount of capital readily available to finance these developments. This has put extreme pressure on the drug development process and specifically on small resource-constrained companies. This makes licensing much more attractive than independently developing the drug. A likely effect is that potential licensees have therefore approached licensing with increasing scrutiny and caution. This should therefore cause a shift in the information asymmetry problem over the course of the analysis.

The limitations discussed here indicate that the results of the analysis should be interpreted with caution. However, the limitations discussed herein also present opportunities for future work in this area.

## VIII References

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## IX Figures

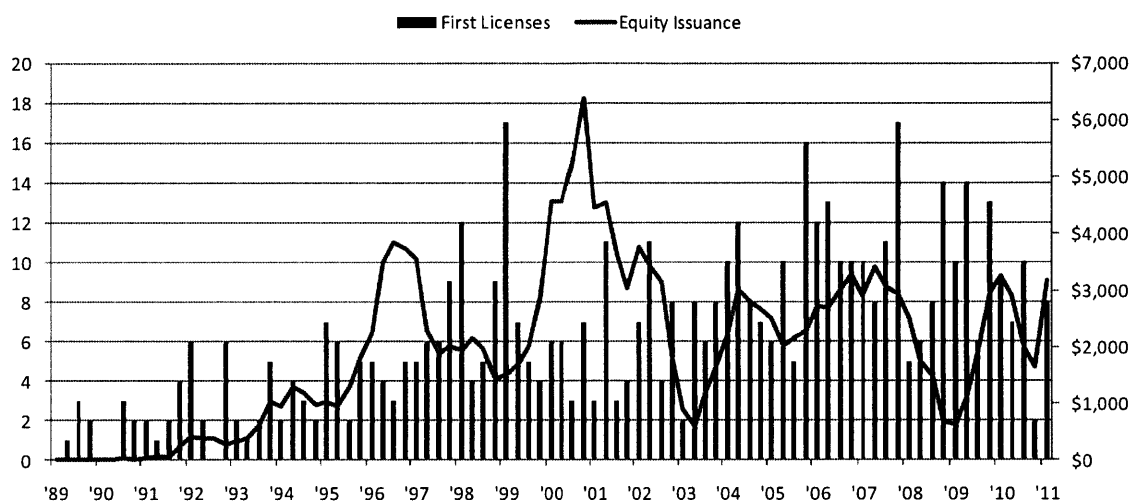
**Figure 1: Descriptive Statistics of Datasets**

The descriptive statistics below are the mean values for the binary variables used in the regression analysis. The mean of  $A_{j,t_0}$  gives the percentage of projects that advanced to the next phase. The mean of  $\Lambda_{t_0}$  gives there percentage of projects that were licensed at the initiation of the specific phase of clinical trials. The mean of  $E_{t_L}$  gives the percentage of projects that were licensed in a low equity issuance period at the initiation of the specific phase of clinical trials. The mean of  $\Gamma_{i,t_0}$  gives the percentage of projects that were originated at firms with concurrent projects at the initiation of the specific phase of clinical trials. The mean of  $\Pi_{i,t_0}$  gives the percentage of projects that were originated at firms that had previously launched projects at the initiation of the specific phase of clinical trials. The mean values for the control variables MS-Mid, MS-High, Formulation, and Biologic are also presented. The number of observations refers to the number of projects that were included in each dataset. Many of the projects were included in multiple datasets and the total number of unique projects is also provided.

	$A_{j,t_0}$	$\Lambda_{t_0}$	$E_{t_L}$	$\Gamma_{i,t_0}$	$\Pi_{i,t_0}$	MS-Mid	MS-High	Formulation	Biologic	Observations
<b>Phase I</b>	<b>44.4%</b>	<b>10.8%</b>	<b>2.4%</b>	<b>90.9%</b>	<b>19.3%</b>	<b>67.1%</b>	<b>18.4%</b>	<b>17.9%</b>	<b>30.1%</b>	<b>1,117</b>
Private	45.7%	8.6%	1.5%	83.6%	12.9%	64.7%	20.3%	17.7%	26.7%	536
Small Public	43.2%	12.9%	3.3%	97.6%	25.3%	69.2%	16.7%	18.1%	33.2%	581
<b>Phase II</b>	<b>25.2%</b>	<b>15.2%</b>	<b>3.6%</b>	<b>90.7%</b>	<b>21.1%</b>	<b>65.0%</b>	<b>19.7%</b>	<b>23.4%</b>	<b>24.3%</b>	<b>828</b>
Private	22.0%	13.9%	2.5%	84.8%	14.9%	62.0%	23.0%	26.8%	21.3%	395
Small Public	28.2%	16.4%	4.6%	96.1%	26.8%	67.7%	16.6%	20.3%	27.0%	433
<b>Phase III</b>	<b>16.7%</b>	<b>27.2%</b>	<b>9.2%</b>	<b>86.3%</b>	<b>26.7%</b>	<b>59.0%</b>	<b>21.0%</b>	<b>23.5%</b>	<b>31.0%</b>	<b>371</b>
Private	15.4%	19.2%	4.6%	75.4%	23.9%	60.8%	22.3%	20.8%	16.9%	130
Small Public	17.4%	31.5%	11.6%	92.1%	28.2%	58.1%	20.3%	24.9%	38.6%	241
Number of unique projects included in analysis										1,738

**Figure 2: Number of First Licenses and Equity Issuance by Quarter**

The chart below displays the number of first licenses in each quarter calculated from the Pharmaprojects database. The amount of moving average of equity issuance from the Bloomberg United States Pharmaceutical Index (BUSPHRM:IND) is plotted in millions of dollars and inflation adjusted to 2011.





### Figure 3

Logistic regression results for Phase I to Phase II advancement for projects originating at private companies using licensing status  $\Lambda_{t_0}$  and licensing in low equity issuance period  $E_{t_L}$  as independent variables.

Figure 3

$A_j(\Phi_{t_0} = 1)$	A	B	C	D	E	F	G	H	I	J
$\lambda$	0.28	0.29	0.28	0.26	0.23					
[S.E.]	[0.31]	[0.31]	[0.31]	[0.31]	[0.33]					
<i>p</i> -value	0.359	0.354	0.361	0.400	0.473					
<b>Odds Ratio</b>	<b>1.33</b>	<b>1.33</b>	<b>1.33</b>	<b>1.30</b>	<b>1.26</b>					
$\varepsilon$						1.29	1.30	1.29	1.46	1.37
[S.E.]						[0.82]	[0.82]	[0.82]	[0.82]	[0.85]
<i>p</i> -value						0.117	0.115	0.116	0.077	0.105
<b>Odds Ratio</b>						<b>3.63</b>	<b>3.65</b>	<b>3.64</b>	<b>4.30</b>	<b>3.95</b>
$\gamma$		0.07	0.08	0.16	0.10		0.08	0.08	0.17	0.11
[S.E.]		[0.23]	[0.24]	[0.24]	[0.25]		[0.24]	[0.24]	[0.24]	[0.25]
<i>p</i> -value		0.756	0.751	0.518	0.690		0.737	0.731	0.489	0.657
<b>Odds Ratio</b>		<b>1.08</b>	<b>1.08</b>	<b>1.17</b>	<b>1.10</b>		<b>1.08</b>	<b>1.08</b>	<b>1.18</b>	<b>1.12</b>
$\pi$			-0.02	-0.04	0.04			-0.03	-0.04	0.04
[S.E.]			[0.26]	[0.27]	[0.28]			[0.26]	[0.26]	[0.28]
<i>p</i> -value			0.933	0.876	0.896			0.922	0.874	0.875
<b>Odds Ratio</b>			<b>0.98</b>	<b>0.96</b>	<b>1.04</b>			<b>0.97</b>	<b>0.96</b>	<b>1.04</b>
$\beta_{MS-Mid}$				-0.10	-0.03				-0.08	-0.01
[S.E.]				[0.25]	[0.29]				[0.25]	[0.30]
<i>p</i> -value				0.692	0.906				0.742	0.973
<b>Odds Ratio</b>				<b>0.91</b>	<b>0.97</b>				<b>0.92</b>	<b>0.99</b>
$\beta_{MS-High}$				0.68	0.54				0.73	0.58
[S.E.]				[0.30]	[0.37]				[0.30]	[0.37]
<i>p</i> -value				0.023	0.143				0.016	0.113
<b>Odds Ratio</b>				<b>1.98</b>	<b>1.71</b>				<b>2.07</b>	<b>1.79</b>
$\beta_{Formulation}$					-0.07					-0.06
[S.E.]					[0.26]					[0.26]
<i>p</i> -value					0.785					0.806
<b>Odds Ratio</b>					<b>0.93</b>					<b>0.94</b>
$\beta_{Biologic}$					-0.10					-0.07
[S.E.]					[0.22]					[0.22]
<i>p</i> -value					0.663					0.749
<b>Odds Ratio</b>					<b>0.91</b>					<b>0.93</b>
<i>TherCodes</i>	N	N	N	N	Y	N	N	N	N	Y
$\alpha$ intercept	-0.20	-0.26	-0.26	-0.40	0.34	-0.19	-0.26	-0.25	-0.42	0.28
[S.E.]	[0.09]	[0.22]	[0.22]	[0.30]	[0.43]	[0.09]	[0.22]	[0.22]	[0.30]	[0.43]
<i>p</i> -value	0.030	0.235	0.239	0.193	0.435	0.030	0.236	0.239	0.166	0.514
	**					**				
Pseudo $R^2$	0.001	0.001	0.001	0.018	0.045	0.004	0.004	0.004	0.022	0.049
Wald <i>p</i> -value	0.092	0.180	0.300	0.009	0.076	0.038	0.084	0.160	0.003	0.047
Observations	536	536	536	536	536	536	536	536	536	536

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%

**Figure 4**

Logistic regression results for Phase I to Phase II advancement for projects originating at small public companies using licensing status  $\Lambda_{t_0}$  and licensing in low equity issuance period  $E_{t_L}$  as independent variables.

Figure 4

$A_1(\Phi_{t_0} = 1)$	A	B	C	D	E	F	G	H	I	J
$\lambda$	0.22	0.22	0.23	0.23	0.20					
[S.E.]	[0.25]	[0.25]	[0.25]	[0.25]	[0.26]					
<i>p</i> -value	0.369	0.367	0.366	0.366	0.445					
<b>Odds Ratio</b>	<b>1.25</b>	<b>1.25</b>	<b>1.25</b>	<b>1.25</b>	<b>1.22</b>					
$\varepsilon$						-0.05	-0.05	-0.04	-0.04	0.11
[S.E.]						[0.47]	[0.47]	[0.47]	[0.47]	[0.49]
<i>p</i> -value						0.922	0.923	0.926	0.938	0.827
<b>Odds Ratio</b>						<b>0.95</b>	<b>0.96</b>	<b>0.96</b>	<b>0.96</b>	<b>1.11</b>
$\gamma$		0.05	0.07	0.08	0.24		0.01	0.03	0.04	0.21
[S.E.]		[0.55]	[0.55]	[0.55]	[0.57]		[0.55]	[0.55]	[0.55]	[0.57]
<i>p</i> -value		0.926	0.905	0.884	0.670		0.982	0.960	0.941	0.712
<b>Odds Ratio</b>		<b>1.05</b>	<b>1.07</b>	<b>1.08</b>	<b>1.28</b>		<b>1.01</b>	<b>1.03</b>	<b>1.04</b>	<b>1.24</b>
$\pi$			-0.13	-0.13	-0.07			-0.13	-0.13	-0.06
[S.E.]			[0.19]	[0.19]	[0.20]			[0.19]	[0.19]	[0.20]
<i>p</i> -value			0.496	0.494	0.747			0.499	0.497	0.756
<b>Odds Ratio</b>			<b>0.88</b>	<b>0.88</b>	<b>0.94</b>			<b>0.88</b>	<b>0.88</b>	<b>0.94</b>
$\beta_{MS-Mid}$				-0.01	-0.27				0.00	-0.25
[S.E.]				[0.25]	[0.31]				[0.25]	[0.31]
<i>p</i> -value				0.962	0.392				0.996	0.418
<b>Odds Ratio</b>				<b>0.99</b>	<b>0.77</b>				<b>1.00</b>	<b>0.78</b>
$\beta_{MS-High}$				0.10	-0.50				0.11	-0.48
[S.E.]				[0.30]	[0.41]				[0.30]	[0.41]
<i>p</i> -value				0.749	0.225				0.722	0.242
<b>Odds Ratio</b>				<b>1.10</b>	<b>0.61</b>				<b>1.11</b>	<b>0.62</b>
$\beta_{Formulation}$					-0.89					-0.91
[S.E.]					[0.27]					[0.27]
<i>p</i> -value					0.001					0.001
<b>Odds Ratio</b>					***					***
					<b>0.41</b>					<b>0.40</b>
$\beta_{Biologic}$					-0.55					-0.55
[S.E.]					[0.19]					[0.20]
<i>p</i> -value					0.005					0.005
<b>Odds Ratio</b>					***					***
					<b>0.58</b>					<b>0.58</b>
<i>TherCodes</i>	N	N	N	N	Y	N	N	N	N	Y
$\alpha$ intercept	-0.30	-0.35	-0.33	-0.36	-0.03	-0.27	-0.28	-0.27	-0.30	0.02
[S.E.]	[0.09]	[0.55]	[0.55]	[0.58]	[0.67]	[0.09]	[0.54]	[0.54]	[0.58]	[0.67]
<i>p</i> -value	0.001	0.518	0.541	0.538	0.962	0.001	0.599	0.624	0.604	0.971
	****					***				
Pseudo $R^2$	0.001	0.001	0.002	0.002	0.038	0.000	0.000	0.001	0.001	0.037
Wald <i>p</i> -value	0.003	0.010	0.018	0.060	0.038	0.005	0.014	0.025	0.079	0.043
Observations	581	581	581	581	581	581	581	581	581	581

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%

**Figure 5**

Logistic regression results for Phase II to Phase III advancement for projects originating at private companies using licensing status  $\Lambda_{t_0}$  and licensing in low equity issuance period  $E_{t_L}$  as independent variables.

Figure 5

$A_1(\Phi_{t_0} = 2)$	A	B	C	D	E	F	G	H	I	J
$\lambda$	0.22	0.23	0.24	0.26	0.36					
[S.E.]	[0.34]	[0.34]	[0.34]	[0.34]	[0.36]					
<i>p</i> -value	0.509	0.500	0.474	0.452	0.319					
<b>Odds Ratio</b>	<b>1.25</b>	<b>1.26</b>	<b>1.27</b>	<b>1.29</b>	<b>1.43</b>					
$\varepsilon$						2.19	2.23	2.25	2.31	2.30
[S.E.]						[0.70]	[0.70]	[0.70]	[0.71]	[0.74]
<i>p</i> -value						0.002	0.002	0.001	0.001	0.002
						***	***	***	***	***
<b>Odds Ratio</b>						<b>8.90</b>	<b>9.31</b>	<b>9.46</b>	<b>10.07</b>	<b>10.00</b>
$\gamma$		-0.50	-0.53	-0.52	-0.52		-0.55	-0.57	-0.56	-0.57
[S.E.]		[0.31]	[0.32]	[0.32]	[0.35]		[0.32]	[0.32]	[0.32]	[0.35]
<i>p</i> -value		0.107	0.094	0.099	0.132		0.085	0.073	0.079	0.103
			*	*			*	*	*	
<b>Odds Ratio</b>		<b>0.60</b>	<b>0.59</b>	<b>0.59</b>	<b>0.59</b>		<b>0.58</b>	<b>0.56</b>	<b>0.57</b>	<b>0.57</b>
$\pi$			0.20	0.21	0.20			0.22	0.23	0.17
[S.E.]			[0.34]	[0.34]	[0.38]			[0.34]	[0.35]	[0.38]
<i>p</i> -value			0.552	0.534	0.603			0.513	0.505	0.651
<b>Odds Ratio</b>			<b>1.22</b>	<b>1.24</b>	<b>1.22</b>			<b>1.25</b>	<b>1.26</b>	<b>1.19</b>
$\beta_{MS-Mid}$				-0.31	-0.19				-0.35	-0.20
[S.E.]				[0.34]	[0.40]				[0.35]	[0.41]
<i>p</i> -value				0.362	0.630				0.307	0.617
<b>Odds Ratio</b>				<b>0.73</b>	<b>0.82</b>				<b>0.70</b>	<b>0.82</b>
$\beta_{MS-High}$				-0.13	0.56				-0.09	0.58
[S.E.]				[0.39]	[0.50]				[0.39]	[0.51]
<i>p</i> -value				0.749	0.263				0.820	0.255
<b>Odds Ratio</b>				<b>0.88</b>	<b>1.75</b>				<b>0.91</b>	<b>1.78</b>
$\beta_{Formulation}$					0.41					0.48
[S.E.]					[0.32]					[0.32]
<i>p</i> -value					0.192					0.129
<b>Odds Ratio</b>					<b>1.51</b>					<b>1.62</b>
$\beta_{Biologic}$					-0.39					-0.51
[S.E.]					[0.35]					[0.37]
<i>p</i> -value					0.272					0.168
<b>Odds Ratio</b>					<b>0.68</b>					<b>0.60</b>
<i>TherCodes</i>	N	N	N	N	Y	N	N	N	N	Y
$\alpha$ intercept	-1.30	-0.88	-0.89	-0.68	-0.56	-1.34	-0.89	-0.90	-0.68	-0.48
[S.E.]	[0.13]	[0.29]	[0.29]	[0.40]	[0.59]	[0.13]	[0.28]	[0.29]	[0.40]	[0.59]
<i>p</i> -value	0.000	0.002	0.002	0.085	0.341	0.000	0.002	0.002	0.090	0.423
	****	***	***	*		****	***	***	*	
Pseudo $R^2$	0.001	0.007	0.008	0.010	0.072	0.026	0.033	0.034	0.037	0.096
Wald <i>p</i> -value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	395	395	395	395	395	395	395	395	395	395

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%

**Figure 6**

Logistic regression results for Phase II to Phase III advancement for projects originating at small public companies using licensing status  $\Lambda_{t_0}$  and licensing in low equity issuance period  $E_{t_L}$  as independent variables.

Figure 6

$A_1(\Phi_{t_0} = 2)$	A	B	C	D	E	F	G	H	I	J
$\lambda$	0.47	0.47	0.47	0.49	0.56					
[S.E.]	[0.27]	[0.27]	[0.27]	[0.28]	[0.30]					
<i>p</i> -value	0.085	0.086	0.085	0.076	0.060					
	*	*	*	*	*					
<b>Odds Ratio</b>	<b>1.60</b>	<b>1.60</b>	<b>1.60</b>	<b>1.64</b>	<b>1.75</b>					
$\varepsilon$						0.99	0.99	0.99	0.94	1.00
[S.E.]						[0.46]	[0.46]	[0.46]	[0.47]	[0.50]
<i>p</i> -value						0.032	0.031	0.032	0.046	0.046
						**	**	**	**	**
<b>Odds Ratio</b>						<b>2.69</b>	<b>2.70</b>	<b>2.69</b>	<b>2.55</b>	<b>2.73</b>
$\gamma$		-0.06	-0.14	0.00	-0.09		-0.12	-0.20	-0.07	-0.17
[S.E.]		[0.55]	[0.55]	[0.56]	[0.61]		[0.54]	[0.55]	[0.56]	[0.60]
<i>p</i> -value		0.917	0.797	0.997	0.879		0.828	0.714	0.901	0.778
<b>Odds Ratio</b>		<b>0.94</b>	<b>0.87</b>	<b>1.00</b>	<b>0.91</b>		<b>0.89</b>	<b>0.82</b>	<b>0.93</b>	<b>0.84</b>
$\pi$			0.37	0.36	0.45			0.36	0.35	0.44
[S.E.]			[0.24]	[0.24]	[0.26]			[0.24]	[0.24]	[0.26]
<i>p</i> -value			0.123	0.133	0.085			0.128	0.139	0.088
					*					*
<b>Odds Ratio</b>			<b>1.44</b>	<b>1.43</b>	<b>1.57</b>			<b>1.43</b>	<b>1.42</b>	<b>1.56</b>
$\beta_{MS-Mid}$				-0.63	-0.18				-0.59	-0.10
[S.E.]				[0.29]	[0.36]				[0.29]	[0.36]
<i>p</i> -value				0.026	0.616				0.039	0.777
				**					**	
<b>Odds Ratio</b>				<b>0.53</b>	<b>0.84</b>				<b>0.55</b>	<b>0.90</b>
$\beta_{MS-High}$				-0.67	0.04				-0.61	0.10
[S.E.]				[0.37]	[0.50]				[0.37]	[0.50]
<i>p</i> -value				0.073	0.939				0.100	0.837
				*						
<b>Odds Ratio</b>				<b>0.51</b>	<b>1.04</b>				<b>0.54</b>	<b>1.11</b>
$\beta_{Formulation}$					0.33					0.29
[S.E.]					[0.31]					[0.31]
<i>p</i> -value					0.290					0.356
<b>Odds Ratio</b>					<b>1.40</b>					<b>1.33</b>
$\beta_{Biologic}$					-0.20					-0.24
[S.E.]					[0.29]					[0.29]
<i>p</i> -value					0.495					0.415
<b>Odds Ratio</b>					<b>0.82</b>					<b>0.79</b>
<i>TherCodes</i>	N	N	N	N	Y	N	N	N	N	Y
$\alpha$ intercept	-1.02	-0.96	-0.99	-0.59	-0.45	-0.99	-0.88	-0.90	-0.53	-0.36
[S.E.]	[0.12]	[0.54]	[0.54]	[0.57]	[0.70]	[0.11]	[0.53]	[0.53]	[0.56]	[0.70]
<i>p</i> -value	0.000	0.073	0.066	0.295	0.523	0.000	0.100	0.092	0.349	0.608
	****	*	*			****		*		
Pseudo $R^2$	0.006	0.006	0.010	0.020	0.070	0.009	0.009	0.013	0.022	0.071
Wald <i>p</i> -value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	433	433	433	433	433	433	433	433	433	433

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%



**Figure 7**

Logistic regression results for Phase III to Launch advancement for projects originating at private companies using licensing status  $\Lambda_{t_0}$  and licensing in low equity issuance period  $E_{t_L}$  as independent variables.

Figure 7

$A_j(\Phi_{\text{to}} = 3)$	A	B	C	D	E	F	G	H	I	J
$\lambda$	0.41	0.41	0.56	0.60	1.22					
[S.E.]	[0.57]	[0.57]	[0.60]	[0.61]	[0.76]					
<i>p</i> -value	0.479	0.479	0.350	0.323	0.112					
<b>Odds Ratio</b>	<b>1.50</b>	<b>1.50</b>	<b>1.76</b>	<b>1.82</b>	<b>3.37</b>					
$\varepsilon$						0.10	0.11	0.18	0.29	0.31
[S.E.]						[1.12]	[1.13]	[1.14]	[1.15]	[1.36]
<i>p</i> -value						0.929	0.924	0.877	0.801	0.818
<b>Odds Ratio</b>						<b>1.11</b>	<b>1.11</b>	<b>1.19</b>	<b>1.34</b>	<b>1.37</b>
$\gamma$		-0.03	-0.20	-0.14	0.20		-0.03	-0.16	-0.13	0.08
[S.E.]		[0.56]	[0.60]	[0.61]	[0.76]		[0.57]	[0.60]	[0.61]	[0.74]
<i>p</i> -value		0.961	0.743	0.823	0.795		0.956	0.784	0.835	0.915
<b>Odds Ratio</b>		<b>0.97</b>	<b>0.82</b>	<b>0.87</b>	<b>1.22</b>		<b>0.97</b>	<b>0.85</b>	<b>0.88</b>	<b>1.08</b>
$\pi$			0.57	0.54	0.42			0.43	0.40	0.23
[S.E.]			[0.60]	[0.60]	[0.74]			[0.57]	[0.57]	[0.71]
<i>p</i> -value			0.340	0.368	0.565			0.453	0.488	0.743
<b>Odds Ratio</b>			<b>1.77</b>	<b>1.71</b>	<b>1.53</b>			<b>1.53</b>	<b>1.49</b>	<b>1.26</b>
$\beta_{\text{MS-Mid}}$				0.02	-0.66				0.01	-0.40
[S.E.]				[0.71]	[0.92]				[0.71]	[0.90]
<i>p</i> -value				0.979	0.469				0.992	0.660
<b>Odds Ratio</b>				<b>1.02</b>	<b>0.52</b>				<b>1.01</b>	<b>0.67</b>
$\beta_{\text{MS-High}}$				0.51	0.72				0.48	0.76
[S.E.]				[0.78]	[0.96]				[0.78]	[0.97]
<i>p</i> -value				0.514	0.450				0.538	0.434
<b>Odds Ratio</b>				<b>1.66</b>	<b>2.06</b>				<b>1.61</b>	<b>2.14</b>
$\beta_{\text{Formulation}}$					-1.01					-0.90
[S.E.]					[0.87]					[0.85]
<i>p</i> -value					0.246					0.289
<b>Odds Ratio</b>					<b>0.36</b>					<b>0.41</b>
$\beta_{\text{Biologic}}$					-2.20					-2.02
[S.E.]					[1.31]					[1.25]
<i>p</i> -value					0.091					0.106
<b>Odds Ratio</b>					<b>0.11</b>					<b>0.13</b>
<i>TherCodes</i>	N	N	N	N	Y	N	N	N	N	Y
$\alpha$ intercept	-1.79	-1.77	-1.83	-2.01	-2.35	-1.71	-1.69	-1.70	-1.85	-2.26
[S.E.]	[0.28]	[0.51]	[0.51]	[0.76]	[1.41]	[0.25]	[0.49]	[0.49]	[0.73]	[1.40]
<i>p</i> -value	0.000	0.000	0.000	0.008	0.097	0.000	0.001	0.000	0.012	0.105
	****	****	****	***	*	****	****	****	**	
Pseudo $R^2$	0.004	0.004	0.012	0.019	0.229	0.000	0.000	0.005	0.011	0.207
Wald <i>p</i> -value	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.011
Observations	130	130	130	130	130	130	130	130	130	130

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%

### Figure 8

Logistic regression results for Phase III to Launch advancement for projects originating at small public companies using licensing status  $\Lambda_{t_0}$  and licensing in low equity issuance period  $E_{t_L}$  as independent variables.

Figure 8

$A_j(\Phi_{\epsilon_0} = 3)$	A	B	C	D	E	F	G	H	I	J
$\lambda$	0.23	0.23	0.21	0.15	0.41					
[S.E.]	[0.36]	[0.36]	[0.36]	[0.37]	[0.41]					
<i>p</i> -value	0.522	0.512	0.565	0.689	0.307					
<b>Odds Ratio</b>	<b>1.26</b>	<b>1.26</b>	<b>1.23</b>	<b>1.16</b>	<b>1.51</b>					
$\epsilon$						0.95	0.95	0.76	0.77	1.13
[S.E.]						[0.45]	[0.45]	[0.46]	[0.47]	[0.52]
<i>p</i> -value						0.034	0.033	0.098	0.099	0.031
						**	**	*	*	**
<b>Odds Ratio</b>						<b>2.58</b>	<b>2.59</b>	<b>2.14</b>	<b>2.16</b>	<b>3.08</b>
$\gamma$		-0.27	-0.29	-0.28	-0.19			-0.27	-0.30	-0.15
[S.E.]		[0.59]	[0.60]	[0.61]	[0.67]			[0.60]	[0.60]	[0.68]
<i>p</i> -value		0.648	0.625	0.649	0.779			0.645	0.623	0.832
<b>Odds Ratio</b>		<b>0.76</b>	<b>0.74</b>	<b>0.76</b>	<b>0.83</b>			<b>0.76</b>	<b>0.74</b>	<b>0.86</b>
$\pi$			0.93	0.89	0.96			0.83	0.80	0.84
[S.E.]			[0.35]	[0.36]	[0.39]			[0.36]	[0.36]	[0.40]
<i>p</i> -value			0.009	0.013	0.013			0.020	0.028	0.035
			***	**	**			**	**	**
<b>Odds Ratio</b>			<b>2.52</b>	<b>2.43</b>	<b>2.62</b>			<b>2.30</b>	<b>2.22</b>	<b>2.31</b>
$\beta_{MS-Mid}$				1.14	1.53				1.16	1.63
[S.E.]				[0.57]	[0.62]				[0.57]	[0.64]
<i>p</i> -value				0.043	0.014				0.041	0.010
				**	**				**	**
<b>Odds Ratio</b>				<b>3.14</b>	<b>4.60</b>				<b>3.18</b>	<b>5.12</b>
$\beta_{MS-High}$				0.58	0.91				0.57	0.91
[S.E.]				[0.67]	[0.73]				[0.67]	[0.74]
<i>p</i> -value				0.387	0.212				0.399	0.220
<b>Odds Ratio</b>				<b>1.79</b>	<b>2.49</b>				<b>1.77</b>	<b>2.49</b>
$\beta_{Formulation}$					-0.59					-0.64
[S.E.]					[0.56]					[0.57]
<i>p</i> -value					0.293					0.262
<b>Odds Ratio</b>					<b>0.56</b>					<b>0.53</b>
$\beta_{Biologic}$					-0.55					-0.61
[S.E.]					[0.44]					[0.44]
<i>p</i> -value					0.209					0.169
<b>Odds Ratio</b>					<b>0.58</b>					<b>0.54</b>
<i>TherCodes</i>	N	N	N	N	Y	N	N	N	N	Y
$\alpha$ intercept	-1.63	-1.39	-1.67	-2.51	-2.68	-1.70	-1.45	-1.68	-2.54	-2.72
[S.E.]	[0.21]	[0.57]	[0.60]	[0.79]	[1.00]	[0.19]	[0.57]	[0.59]	[0.79]	[1.00]
<i>p</i> -value	0.000	0.016	0.005	0.002	0.007	0.000	0.012	0.005	0.001	0.007
	****	**	***	***	***	****	**	***	***	***
Pseudo $R^2$	0.002	0.003	0.033	0.058	0.167	0.019	0.019	0.043	0.069	0.182
Wald <i>p</i> -value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	241	241	241	241	241	241	241	241	241	241

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%

**Figure 9**

Logistic regression results for Phase I to Phase II advancement for licensed projects originating at private companies using equity issuance during the licensing quarter  $EI(Q_{t_L})$  as an independent continuous variable.

$A_j(\Phi_{t_0} = 1)$	A	B	C	D	E
$\mu$	-9.81E-06	-6.41E-05	-1.08E-04	-1.32E-04	-3.09E-04
[S.E.]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
p-value	0.963	0.778	0.642	0.585	0.346
$\gamma$		-1.45	-1.54	-1.35	-1.03
[S.E.]		[0.88]	[0.89]	[0.91]	[1.29]
p-value		0.099	0.083	0.138	0.424
<b>Odds Ratio</b>		<b>0.24</b>	<b>0.21</b>	<b>0.26</b>	<b>0.36</b>
$\pi$			16.95	17.29	20.33
[S.E.]			[2400.00]	[2400.00]	[6523.00]
p-value			0.994	0.994	0.998
<b>Odds Ratio</b>			<b>2.30E+07</b>	<b>3.23E+07</b>	<b>6.75E+08</b>
$\beta_{MS-Mid}$				-1.54	-1.46
[S.E.]				[1.23]	[1.56]
p-value				0.209	0.347
<b>Odds Ratio</b>				<b>0.21</b>	<b>0.23</b>
$\beta_{MS-High}$				-0.72	-0.18
[S.E.]				[1.33]	[2.20]
p-value				0.588	0.935
<b>Odds Ratio</b>				<b>0.49</b>	<b>0.84</b>
$\beta_{Formulation}$					-0.78
[S.E.]					[1.26]
p-value					0.536
<b>Odds Ratio</b>					<b>0.46</b>
$\beta_{Biologic}$					0.59
[S.E.]					[1.03]
p-value					0.565
<b>Odds Ratio</b>					<b>1.81</b>
<i>TherCodes</i>	N	N	N	N	Y
$\alpha_{Intercept}$	0.11	1.44	1.58	2.68	18.58
[S.E.]	[0.61]	[1.06]	[1.08]	[1.59]	[6523.00]
p-value	0.855	0.172	0.144	0.091	0.998
				*	
	0.000	0.050	0.077	0.118	0.268
	0.960	0.430	0.550	0.560	0.000
	46	46	46	46	46

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%

**Figure 10**

Logistic regression results for Phase I to Phase II advancement for licensed projects originating at small public companies using equity issuance during the licensing quarter  $EI(Q_{t_L})$  as an independent continuous variable.

$A_1(\Phi_{t_0} = 1)$	A	B	C	D	E
$\mu$	1.51E-04	1.51E-04	1.51E-04	1.50E-04	2.18E-04
[S.E.]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
p-value	0.447	0.447	0.446	0.458	0.402
$\gamma$		-0.08	-0.07	-0.10	-0.75
[S.E.]		[1.03]	[1.04]	[1.05]	[1.39]
p-value		0.935	0.943	0.921	0.592
<b>Odds Ratio</b>		<b>0.92</b>	<b>0.93</b>	<b>0.90</b>	<b>0.47</b>
$\pi$			-0.03	-0.07	-0.04
[S.E.]			[0.54]	[0.55]	[0.64]
p-value			0.949	0.898	0.945
<b>Odds Ratio</b>			<b>0.97</b>	<b>0.93</b>	<b>0.96</b>
$\beta_{MS-Mid}$				-0.41	0.37
[S.E.]				[0.82]	[1.03]
p-value				0.618	0.716
<b>Odds Ratio</b>				<b>0.66</b>	<b>1.45</b>
$\beta_{MS-High}$				-0.38	1.42
[S.E.]				[0.96]	[1.28]
p-value				0.695	0.266
<b>Odds Ratio</b>				<b>0.69</b>	<b>4.15</b>
$\beta_{Formulation}$					-0.10
[S.E.]					[1.37]
p-value					0.939
<b>Odds Ratio</b>					<b>0.90</b>
$\beta_{Biologic}$					0.81
[S.E.]					[0.64]
p-value					0.209
<b>Odds Ratio</b>					<b>2.24</b>
<i>TherCodes</i>	N	N	N	N	Y
$\alpha$ Intercept	-0.40	-0.32	-0.32	0.09	-1.35
[S.E.]	[0.48]	[1.09]	[1.09]	[1.37]	[2.13]
p-value	0.406	0.770	0.769	0.950	0.527
	0.006	0.006	0.006	0.008	0.159
	0.710	0.870	0.950	0.990	1.000
	75	75	75	75	75

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%

**Figure 11**

Logistic regression results for Phase II to Phase III advancement for licensed projects originating at private companies using equity issuance during the licensing quarter  $EI(Q_{t_L})$  as an independent continuous variable.

$A_j(\Phi_{t_0} = 2)$	A	B	C	D	E
$\mu$	-6.15E-04	-6.35E-04	-6.36E-04	-6.41E-04	-6.31E-04
[S.E.]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
p-value	0.023	0.020	0.020	0.021	0.114
	**	**	**	**	
$\gamma$		1.18	1.23	1.29	20.61
[S.E.]		[1.16]	[1.17]	[1.18]	[9537.00]
p-value		0.310	0.292	0.275	0.998
<b>Odds Ratio</b>		<b>3.26</b>	<b>3.43</b>	<b>3.65</b>	<b>8.93E+08</b>
$\pi$			-0.53	-0.58	-18.91
[S.E.]			[1.26]	[1.26]	[8431.00]
p-value			0.676	0.645	0.998
<b>Odds Ratio</b>			<b>0.59</b>	<b>0.56</b>	<b>6.13E-09</b>
$\beta_{MS-Mid}$				0.71	0.90
[S.E.]				[1.28]	[1.75]
p-value				0.582	0.609
<b>Odds Ratio</b>				<b>2.03</b>	<b>2.45</b>
$\beta_{MS-High}$				0.56	36.90
[S.E.]				[1.41]	[9511.00]
p-value				0.693	0.997
<b>Odds Ratio</b>				<b>1.74</b>	<b>1.06E+16</b>
$\beta_{Formulation}$					37.91
[S.E.]					[8709.00]
p-value					0.997
<b>Odds Ratio</b>					<b>2.91E+16</b>
$\beta_{Biologic}$					0.26
[S.E.]					[1.10]
p-value					0.816
<b>Odds Ratio</b>					<b>1.29</b>
<i>TherCodes</i>	N	N	N	N	Y
$\alpha_{intercept}$	0.29	-0.71	-0.71	-1.36	-58.93
[S.E.]	[0.64]	[1.20]	[1.20]	[1.72]	[2.1E+04]
p-value	0.652	0.553	0.554	0.428	0.998
	0.095	0.116	0.119	0.124	0.612
	0.001	0.003	0.008	0.032	0.000
	55	55	55	55	55

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%

**Figure 12**

Logistic regression results for Phase II to Phase III advancement for licensed projects originating at small public companies using equity issuance during the licensing quarter  $El(Q_{t_L})$  as an independent continuous variable.

$A_1(\Phi_{t_0} = 2)$	A	B	C	D	E
$\mu$	-1.66E-04	-1.23E-04	-1.30E-04	-1.34E-04	-7.59E-05
[S.E.]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
p-value	0.445	0.572	0.552	0.547	0.785
$\gamma$		15.98	16.08	16.10	19.78
[S.E.]		[1385.00]	[1385.00]	[1374.00]	[6107.00]
p-value		0.991	0.991	0.991	0.997
<b>Odds Ratio</b>		<b>8.71E+06</b>	<b>9.63E+06</b>	<b>9.82E+06</b>	<b>3.89E+08</b>
$\pi$			-0.42	-0.41	-0.51
[S.E.]			[0.57]	[0.58]	[0.76]
p-value			0.468	0.482	0.506
<b>Odds Ratio</b>			<b>0.66</b>	<b>0.66</b>	<b>0.60</b>
$\beta_{MS-Mid}$				0.45	0.29
[S.E.]				[0.77]	[1.30]
p-value				0.564	0.820
<b>Odds Ratio</b>				<b>1.56</b>	<b>1.34</b>
$\beta_{MS-High}$				-0.46	-0.07
[S.E.]				[1.08]	[2.30]
p-value				0.673	0.977
<b>Odds Ratio</b>				<b>0.63</b>	<b>0.94</b>
$\beta_{Formulation}$					0.99
[S.E.]					[1.43]
p-value					0.488
<b>Odds Ratio</b>					<b>2.70</b>
$\beta_{Biologic}$					0.53
[S.E.]					[0.67]
p-value					0.428
<b>Odds Ratio</b>					<b>1.71</b>
<i>TherCodes</i>	N	N	N	N	Y
$\alpha$ intercept	-0.21	-16.21	-16.19	-16.48	-19.80
[S.E.]	[0.50]	[1385.00]	[1385.00]	[1374.00]	[6107.00]
p-value	0.679	0.991	0.991	0.990	0.997
	0.006	0.034	0.039	0.055	0.308
	0.067	0.000	0.000	0.500	0.000
	71	71	71	71	71

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%



**Figure 13**

Logistic regression results for Phase III to Launch advancement for licensed projects originating at private companies using equity issuance during the licensing quarter  $EI(Q_{t_L})$  as an independent continuous variable.

$A_1(\Phi_{t_0} = 3)$	A	B	C	D	E
$\mu$	1.53E-05	4.23E-05	5.45E-06	3.67E-04	1.29E-03
[S.E.]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
p-value	0.964	0.908	0.988	0.488	0.548
$\gamma$		-0.99	-0.92	-1.62	-4.32
[S.E.]		[1.08]	[1.08]	[1.49]	[53510.00]
p-value		0.357	0.395	0.276	1.000
<b>Odds Ratio</b>		<b>0.37</b>	<b>0.40</b>	<b>0.20</b>	<b>0.01</b>
$\pi$			-14.95	-16.77	21.55
[S.E.]			[2400.00]	[6523.00]	[62100.00]
p-value			0.995	0.998	1.000
<b>Odds Ratio</b>			<b>3.22E-07</b>	<b>5.21E-08</b>	<b>2.29E+09</b>
$\beta_{MS-Mid}$				18.26	-0.38
[S.E.]				[2750.00]	[54310.00]
p-value				0.995	1.000
<b>Odds Ratio</b>				<b>8.52E+07</b>	<b>0.68</b>
$\beta_{MS-High}$				17.00	14.78
[S.E.]				[2750.00]	[85070.00]
p-value				0.995	1.000
<b>Odds Ratio</b>				<b>2.42E+07</b>	<b>2623447.89</b>
$\beta_{Formulation}$					-18.78
[S.E.]					[30110.00]
p-value					1.000
<b>Odds Ratio</b>					<b>6.98E-09</b>
$\beta_{Biologic}$					-0.95
[S.E.]					[87150.00]
p-value					1.000
<b>Odds Ratio</b>					<b>0.39</b>
<i>TherCodes</i>	N	N	N	N	Y
$\alpha$ intercept	-1.42	-0.77	-0.70	-18.59	-1.59
[S.E.]	[0.85]	[1.09]	[1.10]	[2750.00]	[95090.00]
p-value	0.094	0.481	0.524	0.995	1.000
	*				
	0.000	0.033	0.046	0.186	0.872
	0.021	0.052	0.130	0.000	0.000
	25	25	25	25	25

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%

**Figure 14**

Logistic regression results for Phase III to Launch advancement for licensed projects originating at small public companies using equity issuance during the licensing quarter  $EI(Q_{t_L})$  as an independent continuous variable.

$A_j(\Phi_{t_0} = 3)$	A	B	C	D	E
$\mu$	-6.48E-04	-6.71E-04	-5.80E-04	-6.09E-04	-1.48E-03
[S.E.]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
p-value	0.028	0.030	0.058	0.062	0.030
	**	**	*	*	**
$\gamma$		16.11	16.25	16.07	60.27
[S.E.]		[1611.00]	[1596.00]	[1588.00]	[8407.00]
p-value		0.992	0.992	0.992	0.994
<b>Odds Ratio</b>		<b>9.92E+06</b>	<b>1.14E+07</b>	<b>9.53E+06</b>	<b>1.50E+26</b>
$\pi$			0.67	0.74	1.51
[S.E.]			[0.65]	[0.67]	[1.19]
p-value			0.300	0.269	0.204
<b>Odds Ratio</b>			<b>1.96</b>	<b>2.10</b>	<b>4.53</b>
$\beta_{MS-Mid}$				1.47	20.36
[S.E.]				[1.15]	[3342.00]
p-value				0.200	0.995
<b>Odds Ratio</b>				<b>4.35</b>	<b>6.95E+08</b>
$\beta_{MS-High}$				0.71	18.42
[S.E.]				[1.36]	[3342.00]
p-value				0.603	0.996
<b>Odds Ratio</b>				<b>2.03</b>	<b>9.99E+07</b>
$\beta_{Formulation}$					-0.23
[S.E.]					[1.42]
p-value					0.873
<b>Odds Ratio</b>					<b>0.80</b>
$\beta_{Biologic}$					0.20
[S.E.]					[1.16]
p-value					0.864
<b>Odds Ratio</b>					<b>1.22</b>
<i>TherCodes</i>	N	N	N	N	Y
$\alpha$ intercept	-0.35	-16.34	-16.85	-17.82	-80.51
[S.E.]	[0.50]	[1611.00]	[1596.00]	[1588.00]	[10210.00]
p-value	0.489	0.992	0.992	0.991	0.994
	0.085	0.114	0.127	0.161	0.554
	0.000	0.000	0.000	0.004	0.000
	76	76	76	76	76

Significance Code: \*\*\*\* 0.1%; \*\*\* 1%; \*\* 5%; \* 10%