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大型企業會提早購買創意嗎？以生技製藥產業為例

Does a Large Firm Buy Ideas Early? Theory and Evidence from the Biopharmaceutical Industry

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中文摘要

企業透過授權交易商業化創新對於獲取競爭優勢至關重要，特別是在生技製藥產業中。本研究建構一個兩期連續投資模型，分析被授權方在授權交易中的抉擇，即應於早期階段簽署授權契約，或延遲至後期再進行投資。理論上，市值較大的企業更傾向於承擔風險，並在創新開發的早期即購買創意，以促進產品開發與商業化，從而建立市場競爭優勢。本研究運用生技製藥產業的授權交易數據，探討被授權方的市值是否以及在何種程度上影響授權交易的時機。實證結果顯示，當被授權方的市值增加時，授權交易的發生時機顯著提前，且此趨勢無論企業規模大小皆成立。此外，相較於中小型企業，大型企業在早期階段購買創意的可能性顯著更高。本研究的發現可為生技製藥產業的商業開發與授權專業人士提供參考，協助其制定策略，在全球市場中尋找早期創新項目的潛在買家。

關鍵字：創意銷售、授權、生技製藥產業、市值、連續投資、創新商業化

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ABSTRACT

The commercialization of innovation through licensing is essential for firms seeking competitive advantages, particularly in the biopharmaceutical industry. This study constructs a two-stage sequential investment model to examine the decision-making process of licensees: whether to enter into licensing agreements during the early stages of innovation or to delay investment until later phases. Theoretically, firms with higher market capitalization are more likely to assume greater risk and engage in early-stage licensing to accelerate product development and commercialization, thereby enhancing their market positioning. Utilizing a dataset of licensing transactions in the biopharmaceutical sector, this research investigates whether, and to what extent, a licensee's market capitalization influences the timing of licensing decisions. Empirical findings reveal that an increase in market capitalization is significantly associated with earlier licensing, and this relationship holds consistently across firms of varying sizes. Furthermore, large firms demonstrate a substantially greater likelihood of acquiring innovation at early stages compared to small and medium-sized counterparts. These results offer practical insights for professionals involved in business development and licensing in the biopharmaceutical field, supporting strategic efforts to identify early-stage innovations and their potential buyers in global markets.

Keywords: sale of ideas, licensing, biopharmaceutical industry, market capitalization, sequential investment, innovation commercialization

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Chapter 1 Introduction

In industries driven by human creativity—such as film and biopharmaceutical sectors—the commercialization of ideas through licensing is both prevalent and strategically important. Examples range from selling adapted screenplays based on novels in the film industry to licensing early-stage scientific discoveries for new therapeutic uses in the biopharmaceutical industry. A recurring theme in the literature concerns the timing of idea transactions—specifically, the optimal moment to sell. While the sale of ideas unlocks commercial value from intellectual creativity, achieving mutually beneficial timing for both buyers and sellers remains a complex challenge due to information asymmetries and market uncertainties. This study addresses this central issue: when is the optimal timing to sell an idea? It focuses on the timing of licensing in the biopharmaceutical industry by developing a theoretical model and analyzing empirical evidence.

On February 28, 2023, a U.S.-based specialty pharmaceutical firm, known for its focus on rare and neurological disorders, announced an exclusive licensing agreement with a Taiwanese clinical-stage biotech startup. The licensed product, a first-in-class clinical asset, was in Phase 1b/2a trials in the U.S., and the potential deal value was approximately USD 250 million[1]. This deal exemplifies how early-stage licensing can serve as a pivotal mechanism for both innovation commercialization and survival,

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[1] Please see the news release at: https://ir.avenuetx.com/news-events/press-releases/detail/65/avenue-therapeutics-enters-into-a-transformational-license, (Last visited: Nov.11, 2023)

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particularly for emerging biotech firms[2]. For Taiwanese biotech startups, transitioning innovations from laboratory to market is not merely strategic, but is existential. On a broader scale, Taiwan's government sees the biopharmaceutical sector as the nation's next growth engine, aiming to replicate the global success of its semiconductor industry. Through incentives and venture capital funding, the Taiwanese government has actively fostered an environment conducive to biotech innovation. The result is a national agenda in which fostering early-stage transactions in biopharma is a key pillar.

Biotech is a science-intensive industry that leverages biological and molecular tools to develop healthcare solutions, whereas the pharmaceutical sector encompasses the R&D, production, and distribution of therapeutic products[3]. According to IQVIA, the global pharmaceutical market reached USD 1.42 trillion in 2021[4], up from USD 1.27 trillion in 2019, and further increased to USD 1.48 trillion in 2022[5]. These figures highlight the rising global investment in healthcare and the growing economic importance of the biopharmaceutical sector.

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[2] Despite that this partnership has been readjusted and a new agreement was executed to replace the original license agreement on April 24, 2025, this partnership still represented a benchmark of early licensing for clinical Phase 1 asset between an emerging Taiwan biotech firm and a U.S. specialty biotech company. See https://www.ctee.com.tw/news/20250424702062-430503 (last visited: April 26, 2025)

[3] See https://www.investopedia.com/terms/b/biotechnology.asp, (last visited: Sep.03, 2023)

[4] See *"2022 Biotech Industry in Taiwan"*, P5.

[5] See https://www.statista.com/topics/1764/global-pharmaceutical-industry/#topicOverview, (last visited: Sep 03, 2023)

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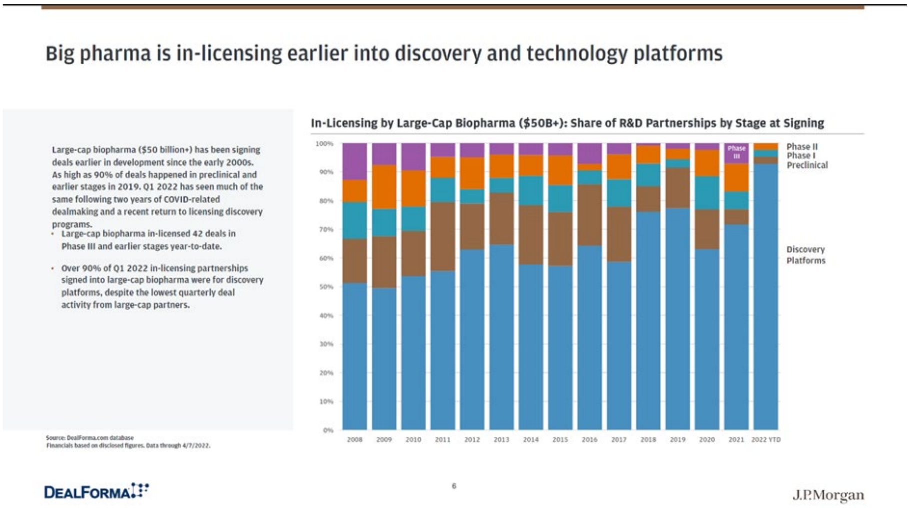
The biopharmaceutical industry, characterized by lengthy development cycles and high failure rates, is particularly capital-intensive and heavily reliant on robust intellectual property (IP) protections, especially patents and trade secrets. Securing funding to sustain drug development across multi-phase trials remains a persistent challenge. Within this context, licensing arrangement as a strategic mechanism not only to distribute financial and developmental risks, but also to expedite the commercialization process by leveraging external partnerships.

From an economic standpoint, IP rights incentivize investment in innovation while also serving as signals to potential partners. Project owners frequently seek licensing deals to offset risk and attract collaborators for further development. Evidence from JP Morgan's 2022 report "*Biopharma Therapeutics Licensing Deals and Venture*" as Figure 1 on licensing trends shows that large pharmaceutical companies increasingly target earlier-stage innovations, particularly in discovery and platform technologies.

Figure 1: The In-Licensing by Large-Cap Biopharma in 2022[6]



6 See https://www.jpmorgan.com/content/dam/jpm/commercial-banking/insights/life-sciences/jpmorgan-q2-2023-biopharma-licensing-and-venture-report.pdf, (last visted: Mar.02, 2025)

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The rationale for early licensing is rooted in the complexity and cost of drug development. From an initial discovery through pre-clinical and multi-phase clinical trials, the process is fraught with risk but promises significant financial rewards upon successful market approval. To manage this uncertainty, smaller biotech firms often license their innovations to larger players who possess the resources and expertise needed for later-stage development and commercialization.

This paper links licensing to investment behavior by modeling the licensee as an investor in the licensor's technology. The core research question is: How does a licensee's firm size influence the timing of its licensing decisions? Firm size is proxied using market capitalization, which reflects investor confidence and the firm's ability to finance risky ventures. The hypothesis is that larger firms, due to their higher tolerance to burden investment with no return and stronger resource base, are more inclined to engage in early-stage licensing to secure market position. Despite that big pharma may be likely to delay its licensing to acquire the innovation at a mature stage for optimizing its shareholder's short-term interests from a practical perspective, we still assume that large firms tend to license early. This assumption is based on the fact the first leader launching the new drug to the market will share a legitimate status of market exclusivity with patent protection or regulatory incentives (for example, an orphan drug for rare disease will share additional 10 years in the EU market[7]) for a long period of time, and a new drug project at a later stage will bring higher intense competition. Early licensing, under this

[7] See https://www.ema.europa.eu/en/human-regulatory-overview/post-authorisation/orphan-designation-post-authorisation/market-exclusivity-orphan-medicines, (last visited: April 26, 2025)

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circumstance, will be more likely to optimize shareholders' short-term interest and long-term value than delay licensing. In this regard, we conduct our research based on the assumptions that large firms prefer early licensing.

To address this question, we develop a two-stage sequential investment model that captures the strategic considerations of both licensors and licensees. The model is tested using empirical data from biopharmaceutical licensing deals, enabling us to assess the relationship between firm size and licensing timing. The remainder of this paper is structured as follows: Chapter 2 reviews the relevant literature. Chapter 3 presents the theoretical model and the associated investment decisions. Chapter 4 describes the empirical model, data sources, and results. Chapter 5 discusses the findings in relation to the theoretical framework. Finally, Chapter 6 concludes and outlines avenues for future research.

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Chapter 2 Literature Review

The sale of ideas typically involves an inherent information asymmetry between sellers and buyers, wherein sellers possess superior knowledge about the quality and potential of the idea. This imbalance often delays buyer decision-making and results in a sequential evaluation process. As such, determining the optimal timing for idea transactions becomes a strategic concern for both parties, akin to investment decisions under uncertainty. Bar-Ilan and Strange (1998), for instance, develop a two-stage sequential investment model to analyze decisions related to capital-intensive activities, including pharmaceutical R&D.

Expanding on this, Tsai and Kung (2011) apply a two-stage sequential investment framework to explore how adverse selection and the transfer of know-how affect organizational structure. Their research demonstrates that such models are particularly relevant for understanding complex transactions under asymmetric information, such as the sale of ideas. Building on this foundation, this paper adopts a similar modeling approach to examine the decision-making trade-offs faced by licensees in biopharmaceutical licensing.

From a market perspective, the "market for technology" refers to a system where innovation is commercialized through transactions, such as licensing or joint ventures, thereby facilitating specialization and the division of labor. Lamoreaux and Sokoloff (1996) document how the 19th-century emergence of technology markets enabled inventors to focus on ideation, while commercialization was delegated to specialized firms. Arora and Gambardella (2010) further emphasize that these markets intensify downstream competition while accelerating technological diffusion. Transactions

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typically involve IP rights such as patents and trade secrets and may take various forms including R&D collaborations, co-development, and mergers & acquisitions.

In the context of creative industries, Luo (2014) examines idea sales in the movie sector. She develops a game-theoretic model to describe the interaction between buyers and sellers, revealing that inexperienced sellers often delay disclosure to enhance perceived value, while established sellers can transact ideas at any point. Her empirical analysis, based on a dataset from the original movie idea market, confirms that experienced sellers attract more buyer interest due to reduced perceived risk. This insight underlines the role of seller reputation in shaping market dynamics.

Licensing in the biopharmaceutical industry has been widely studied. Kollmer and Dowling (2004) explore the differences in licensing strategies between firms that focus solely on drug discovery and those that are vertically integrated. Their findings indicate that a majority of firms (78.6%) in their sample pursue licensing before or during Phase I/II clinical trials. Furthermore, larger firms, as measured by revenue, R&D budgets, and employee counts, are more likely to have established sales and marketing capabilities, which affects their timing and approach to licensing agreements.

Allain, Henry, and Kyle (2016) investigate how the timing of idea sales influences efficiency. Their study shows that the level of competition in downstream markets significantly affects licensing behavior: more competitors tend to delay licensing, while the presence of established market players reduces delays. They construct a two-period theoretical model to explain how market structure shapes the timing of transactions and validate their predictions using biopharmaceutical licensing data.

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Further research by Song and Lee (2023) examines the role of a licensee's network and reputation in licensing decisions. Their empirical results demonstrate that firms with extensive networks and strong reputations are more likely to engage in early-stage licensing. Conversely, firms with weaker or less connected networks tend to avoid early licensing, even if they enjoy a good reputation. These findings suggest that structural position within a network amplifies the benefits of reputational capital.

Some studies also link licensing behavior to signaling theory. Cabaleiro-Cerviño and Burcharth (2020) assess whether licensing agreements influence investor perceptions and firm valuation. Their findings, based on firms in the S&P 500, indicate that inward licensing agreements often send negative signals to investors—especially when firms lack robust innovation capabilities. However, this signaling effect diminishes in firms with broad analyst coverage.

Meschnig and Dubiel (2023) provide a comprehensive literature review of licensing studies, identifying five promising research directions: (1) the branding impact of licensing, (2) motivations and behavior of licensees, (3) theoretical diversity in analysis, (4) success criteria for licensing performance, and (5) more granular empirical approaches. Their review highlights the need for more studies from the licensee's perspective, with stronger theoretical grounding and detailed empirical evidence.

Finally, Thomas and Chugan (2020) explore the determinants of licensing deals in the pharmaceutical industry. Using a dataset of 101 firms and 381 deals from 2011 to 2015, they identify company size, R&D expenditure, revenue, employee count, and firm age as significant factors. Their analysis reveals that licensors tend to favor partners with

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larger R&D budgets and workforce capacity. This finding supports the rationale for examining how firm size impacts licensing behavior.

In summary, existing literature covers various dimensions of licensing—from timing and market structure to reputation and signaling. However, few studies focus specifically on how a licensee's financial capacity, particularly market capitalization, influences the timing of licensing. This study aims to address that gap by integrating theoretical modeling with empirical analysis, providing a novel perspective on early versus late-stage idea transactions in the biopharmaceutical sector.

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Chapter 3 Theoretical Model

While existing literature has examined how licensing decisions relate to market structure, reputation, and signaling, fewer studies have explored the influence of the licensee's financial capacity, particularly firm size, on the timing of licensing. This chapter aims to fill that gap by introducing a theoretical framework that connects a licensee's market capitalization to its willingness to license early.

To do so, we construct a two-stage sequential investment model that captures the key trade-offs faced by licensees deciding when to engage in a licensing agreement. The central idea is to model the licensee as an investor in the licensor's innovation, who must choose between early and late-stage investment. The timing of the investment impacts the probability of success, the allocation of risk, and the bargaining dynamics between the two firms.

3.1 Two-Stage Sequential Investment Model

Consider two firms:

Firm 1 (Licensor) owns an innovative project and holds IP rights.

Firm 2 (Licensee) is a potential commercialization partner with the option to invest in Firm 1's innovations.

The innovation process unfolds over two phases: Phase I and Phase II. In each phase, firms must decide whether to invest, with associated costs and uncertain outcomes.

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In Phase t, Firm 1 makes its investment decision $x_t \in \{0,1\}$ with a cost $c_t x_t$. On the other hand, Firm 2 can either invest $y_1 = 1$ (and so $y_2 = 0$) in Phase I with a cost d_1 or $y_2 = 1$ (and so $y_1 = 0$) in Phase II with a cost d_2. Therefore, the total investment is in Phase t is $I_t = x_t + y_t$.

At the end of Phase I, the midterm outcome ω_1 is realized, which can be a success ($\omega_1 = s$) or a failure ($\omega_1 = f$). The probability of obtaining a successful outcome is $q_1(I_1)$, which depends on the total investment level in Phase I. At the end of Phase II, the final outcome ω_2 is realized, which can be a success ($\omega_2 = S$) or a failure ($\omega_2 = F$). The probability of obtaining a successful outcome is $q_2(I_2, \omega_1)$, which depends on both the investment level in Phase II and the midterm outcome in Phase I.

We make the following assumptions:

Assumptions.

1. $q_1(I_1)$ *is increasing in* I_1.

2. $q_2(I_2, \omega_1)$ *is increasing in* I_2 *given* ω_1.

3. $q_2(I_2, s) > q_2(I_2, f)$ *given* I_2.

4. $q_2(2, s) - q_2(1, s) = q_2(2, f) - q_2(1, f) = \alpha$.

Assumption 1 and 2 mean that a higher investment level increases the probability of obtaining a successful midterm and final results. Assumption 3 means that a successful outcome in Phase I gives a higher probability of success to the final outcome than a failure outcome. Assumption 4 means that the gain in the success probability from an extra investment is invariant with the first-period outcome.

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When Firm 2 decides to invest, they also decide a contract to transfer the technology that specifies the payment that Firm 2 needs to pay Firm 1 when the final outcome is a success. If Firm 1 fails to develop the innovation successfully, there is no payment transfer between them. We assume that the licensing fee $\phi \geq 0$ is determined by Nash bargaining.

The setup regarding the timing of investment/contracting reflects the main trade-off in this model: postponing the investment decision allows Firm 2 to wait for the extra information of the midterm outcome. However, since the final outcome is affected by the midterm outcome, it may be better for Firm 2 to invest earlier to increase the probability of success.

We assume that, without the new technology, Firm 1 and Firm 2 earn u and v, respectively. If the innovation is successfully developed, it gives Firm 1 an extra profit Δu, and if Firm 2 obtains the new technology through a licensing contract, it earns an extra Δv.

This Δv can capture the Firm 2's "net return" from its investment. We categorize a "large" firm and a "small" firm based on its market capitalization. We would like to study whether a large firm tends to invest in Phase I because it is more willing to take more risk at an early stage to capture potential market share, while a small firm is more likely to invest in Phase II due to its limited capital which needs to focus on investing in a more mature project close to being launched on the market. In other words, the firm size is the key factor for a potential licensee to determine the timing of investment.

The procedure of the game is the following:

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Phase I:

- Firm 1 makes the investment decision $x_1 \in \{0,1\}$.

- Firm 2 can decide whether to invest in this phase or to postpone it to the next phase. If Firm 2 invests in this phase, then $y_1 = 1$. Then they make a contract that specifies the licensing fixed fee $\phi \geq 0$ that Firm 2 needs to pay Firm 1 if the final outcome is a success.

- The outcome of this phase ω_1 is realized. Then the game proceeds to Phase II.

Phase II:

- Firm 1 makes the investment decision $x_2 \in \{0,1\}$.

- If Firm 2 did not invest in Phase I, it can decide whether to invest in this phase. If Firm 2 invests in this phase, then $y_2 = 1$. Then they make a contract that specifies the licensing fixed fee in case of a successful final outcome.

- The final outcome of the project ω_2 is realized. The payoffs for both firms are realized.

Payoff for each firm:

There are several cases to consider, depending on the investment decisions. We will focus on the case where Firm 1 makes investment in both phases, and study Firm 2's optimal timing of investment.

There are three cases to consider, and we list the firms' payoffs under each scenario:

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Case 1: $x_1 = x_2 = 1,\ y_1 = 1$

$$\pi_1 = q_1(2)\{q_2(1,s)(u + \Delta u + \phi) + [1 - q_2(1,s)]u\}$$

$$+[1 - q_1(2)]\{q_2(1,f)(u + \Delta u + \phi) + [1 - q_2(1,f)]u\} - c_1 - c_2,$$

$$\pi_2 = q_1(2)\{q_2(1,s)(v + \Delta v - \phi) + [1 - q_2(1,s)]v\}$$

$$+[1 - q_1(2)]\{q_2(1,f)(v + \Delta v - \phi) + [1 - q_2(1,f)]v\} - d_1.$$

Case 2: $x_1 = x_2 = 1,\ y_2 = 1$ regardless of ω_1

$$\pi_1 = q_1(1)\{q_2(2,s)(u + \Delta u + \phi) + [1 - q_2(2,s)]u\}$$

$$+[1 - q_1(1)]\{q_2(2,f)(u + \Delta u + \phi) + [1 - q_2(2,f)]u\} - c_1 - c_2,$$

$$\pi_2 = q_1(1)\{q_2(2,s)(v + \Delta v - \phi) + [1 - q_2(2,s)]v\}$$

$$+[1 - q_1(1)]\{q_2(2,f)(v + \Delta v - \phi) + [1 - q_2(2,f)]v\} - d_2.$$

Case 3: $x_1 = x_2 = 1,\ y_2 = 1$ if and only if $\omega_1 = s$

$$\pi_1 = q_1(1)\{q_2(2,s)(u + \Delta u + \phi) + [1 - q_2(2,s)]u\}$$

$$+[1 - q_1(1)]\{q_2(1,f)(u + \Delta u + \phi) + [1 - q_2(1,f)]u\} - c_1 - c_2,$$

$$\pi_2 = q_1(1)\{q_2(2,s)(v + \Delta v - \phi) + [1 - q_2(2,s)]v - d_2\} + [1 - q_1(1)]v.$$

3.2 The Optimal Contract and Investment Decision

The equilibrium concept is the subgame perfect Nash equilibrium, and thus we apply backward induction to solve the game. For each scenario, we will need to find out the

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condition to support it as an equilibrium and then compare all the scenarios to find the optimal investment decision for each firm, x_t and y_t, as well as the optimal contract which specifies the licensing fee ϕ determined by Nash bargaining.

3.2.1 *Firm 2's investment decision in Phase II: Later investment*

We start with Case 3.

Case 3: $x_1 = x_2 = 1,\ y_2 = 1$ if and only if $\omega_1 = s$

In this case, if $\omega_1 = f$, Firm 2 will not invest and so no contract is needed, while if $\omega_1 = s$, Firm 2 will invest. Therefore, the contract contains the license fee for $\omega_1 = s$, denoted by ϕ_s. Then given $\omega_1 = s$, if Firm 1 accepts the contract, it obtains:

$$\pi_1 = q_2(2, s)(u + \Delta u + \phi_s) + [1 - q_2(2, s)]u - c_1 - c_2$$

in Phase II, while if it rejects the contract, it obtains:

$$q_2(1, s)(u + \Delta u) + [1 - q_2(1, s)]u - c_1 - c_2 \equiv \sigma_1.$$

σ_1 is the "disagreement payoff" when the bargaining breaks down. In this case, Firm 1 does not receive the fee ϕ_s and the probability of success is also lower when Firm 2 does not invest—$q_2(1, s) < q_2(2, s)$.

In terms of Firms 2's decision, if it accepts the contract, its payoff in Phase II is:

$$\pi_2 = q_2(2, s)[v + \Delta v - \phi_s] + [1 - q_2(2, s)]v - d_2,$$

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while if Firm 2 rejects the contract, it obtains v, which means that the technology is not transferred, nor is the investment made. This v is Firm 2's disagreement payoff, denoted by σ_2.

The optimal licensing fee is determined by Nash bargaining. We assume that the bargaining power of Firm 1 is β and that of Firm 2 is $1-\beta$. Then the optimal ϕ_s is the solution to the following problem:

$$\max_{\phi_s} \ (\pi_1-\sigma_1)^{\beta}(\pi_2-\sigma_2)^{1-\beta}$$

$$= \{[q_2(2,s)-q_2(1,s)]\Delta u + q_2(2,s)\phi_s\}^{\beta}\{q_2(2,s)\Delta v - q_2(2,s)\phi_s - d_2\}^{1-\beta}. \quad \text{... (1)}$$

The first-order condition is:

$$\beta[q_2(2,s)\Delta v - q_2(2,s)\phi_s - d_2] = (1-\beta)\{[q_2(2,s)-q_2(1,s)]\Delta u + q_2(2,s)\phi_s\}.$$

The Nash bargaining solution is:

$$\phi_s^* = \frac{\beta[q_2(2,s)\Delta v - d_2] - (1-\beta)[q_2(2,s)-q_2(1,s)]\Delta u}{q_2(2,s)} \equiv \tilde{\phi}_s \quad \text{... (2)}$$

If this $\tilde{\phi}_s < 0$, then the solution is at the corner, i.e., $\phi_s^* = 0$, because the fee cannot be negative, i.e., $\phi_s^* \geq 0$. Therefore, we have the following lemma:

Lemma 1. *If the equilibrium is one where* $x_1 = x_2 = 1$, *and* $y_2 = 1$ *if and only if* $\omega_1 = s$, *then the optimal licensing fee under Nash bargaining is* $\phi_s^* = \tilde{\phi}_s > 0$ *if* $\Delta v > \kappa_s$, *and* $\phi_s^* = 0$ *if* $\Delta v \leq \kappa_s$, *where* $\kappa_s = \frac{(1-\beta)[q_2(2,s)-q_2(1,s)]\Delta u + \beta d_2}{\beta q_2(2,s)}$.

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Lemma 1 claims that when the benefit of having the new technology for Firm 2 is sufficiently large ($\Delta v > \kappa_s$), the optimal licensing fee is positive (i.e., Firm 2 needs to pay a positive fee to Firm 1 for getting the new technology), but if the benefit is small ($\Delta v \leq \kappa_s$), it would not pay any positive licensing fee. In addition, the bargaining power of each firm further determines the licensing fee Firm 2 will pay to Firm 1, where Firm 2 will pay more when $1-\beta > \beta$, while it pays less if $1-\beta < \beta$. The bargaining power of each firm depends on how competitive the market for this innovation is. If Firm 1 has more candidates to license its innovation, it has more bargaining power than Firm 2, and vice versa.

By substituting the optimal licensing fee into Firm 2's payoff, we have:

$$\pi_2 = q_1(1)\{q_2(2,s)(v+\Delta v-\phi_s^*)+[1-q_2(2,s)]v-d_2\}+[1-q_1(1)]v$$

$$= \begin{cases} v+(1-\beta)q_1(1)\{[q_2(2,s)\Delta v-d_2]+[q_2(2,s)-q_2(1,s)]\Delta u\}, & \text{if } \Delta v > \kappa_s, \\ v+q_2(2,s)\Delta v-d_2, & \text{if } \frac{d_2}{q_2(2,s)} \leq \Delta v \leq \kappa_s. \\ v & \text{if } \Delta v < \frac{d_2}{q_2(2,s)}. \end{cases} \quad \dots(3)$$

Note that if Firm 2 does not invest, it obtains at least v. It can be seen by (3) that Firm 2 will invest in Phase II only when $\Delta v > \frac{d_2}{q_2(2,s)}$, otherwise, it would rather not invest.

<u>Case 2</u>: $x_1 = x_2 = 1,\ y_2 = 1$ regardless of ω_1

In this case, Firm 2 invests in Phase II no matter what the first-period outcome is. The contract then specifies the licensing fee contingent on ω_1, i.e., (ϕ_s, ϕ_f).

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When $\omega_1 = s$, the analysis is the same as that in Case 3, and the optimal licensing fee under Nash bargaining is $\phi_s^* = \tilde{\phi}_s$, as specified in Lemma 1. On the other hand, when $\omega_1 = f$, if Firm 1 accepts the contract, it obtains:

$$\pi_1 = q_2(2,f)\left(u + \Delta u + \phi_f\right) + [1 - q_2(2,f)]u - c_1 - c_2$$

in Phase II, while if it rejects the contract, it obtains:

$$q_2(1,f)(u + \Delta u) + [1 - q_2(1,f)]u - c_1 - c_2 \equiv \sigma_1'.$$

As for Firm 2, if it accepts the contract, its payoff in Phase II is:

$$\pi_2 = q_2(2,f)\left[v + \Delta v - \phi_f\right] + [1 - q_2(2,f)]v - d_2,$$

while if Firm 2 rejects the contract, it obtains $v \equiv \sigma_2'$.

Again, we use the Nash bargaining to solve the following problem:

$$\max_{\phi_f} \ (\pi_1 - \sigma_1')^{\beta}(\pi_2 - \sigma_2')^{1-\beta}$$

$$= \left\{[q_2(2,f) - q_2(1,f)]\Delta u + q_2(2,f)\phi_f\right\}^{\beta}\left\{q_2(2,f)\Delta v - q_2(2,f)\phi_f - d_2\right\}^{1-\beta}. \quad \text{... (4)}$$

The first-order condition is:

$$\beta\left[q_2(2,f)\Delta v - q_2(2,f)\phi_f - d_2\right] = (1-\beta)\left\{[q_2(2,f) - q_2(1,f)]\Delta u + q_2(2,f)\phi_f\right\}.$$

The Nash bargaining solution is:

$$\phi_f^* = \frac{\beta[q_2(2,f)\Delta v - d_2] - (1-\beta)[q_2(2,f) - q_2(1,f)]\Delta u}{q_2(2,f)} \equiv \tilde{\phi}_f. \quad \text{... (5)}$$

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If $\tilde{\phi}_f < 0$, then the solution is at the corner, i.e., $\phi_f^* = 0$. Therefore, we have the following lemma:

Lemma 2. *If the equilibrium is one where* $x_1 = x_2 = 1$, *and* $y_2 = 1$ *regardless of* ω_1, *then:*

(1) The optimal licensing fee under Nash bargaining is $(\phi_s^*, \phi_f^*) = (\tilde{\phi}_s, \tilde{\phi}_f)$ *if* $\Delta v > \kappa_{\omega_1}$, *and* $\phi_{\omega_1}^* = 0$ *if* $\Delta v \leq \kappa_{\omega_1}$, *where* $\kappa_{\omega_1} = \frac{(1-\beta)[q_2(2,\omega_1)-q_2(1,\omega_1)]\Delta u+\beta d_2}{\beta q_2(2,\omega_1)}$, *where* $\omega_1 = s, f$.

(2) $\phi_s^* \geq \phi_f^*$ *and* $\kappa_s < \kappa_f$.

Lemma 2-(1) is analogous to Lemma 1. Lemma 2-(2) is obtained by Assumptions 3 and 4. Note that:

$$\tilde{\phi}_{\omega_1} = \beta(\Delta v - \kappa_{\omega_1}).$$

$\phi_s^* \geq \phi_f^*$ implies that Firm 2 is willing to pay a higher licensing fee if the first-period outcome is a success than a failure. Since the successful first period outcome ensures a higher probability to final outcome, more potential licensee will approach Firm 1 to propose a license deal at Stage 2, which strengthens the bargaining power of Firm 1 to negotiate licensing fee with Firm 2. $\kappa_s < \kappa_f$ means that in order for Firm 2 to pay a positive licensing fee, Δv needs to be larger if the first-period outcome is a failure than a success.

By substituting the optimal licensing fee into Firm 2's payoff, we have:

$\pi_2 = q_1(1)\{q_2(2,s)(v + \Delta v - \phi_s^*) + [1 - q_2(2,s)]v\}$

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$$+[1-q_1(1)]\{q_2(2,f)(v+\Delta v-\phi_f^*)+[1-q_2(2,f)]v\}-d_2.$$

$$=$$

$$\begin{cases} v+(1-\beta)\left\{\begin{matrix} q_1(1)\left[(q_2(2,s)\Delta v-d_2)+\big(q_2(2,s)-q_2(1,s)\big)\Delta u\right] \\ +[1-q_1(1)]\left[(q_2(2,f)\Delta v-d_2)+\big(q_2(2,f)-q_2(1,f)\big)\Delta u\right]\end{matrix}\right\}, & \text{if } \Delta v>\kappa_f, \\ v+(1-\beta)q_1(1)\left[(q_2(2,s)\Delta v-d_2)+\big(q_2(2,s)-q_2(1,s)\big)\Delta u\right] \\ \quad +[1-q_1(1)](q_2(2,f)\Delta v-d_2), & \text{if } \kappa_s<\Delta v\le\kappa_f \\ v+q_2(2,s)\Delta v-d_2, & \text{if } \frac{d_2}{q_2(2,s)}\le\Delta v\le\kappa_s, \\ v & \text{if } \Delta v<\frac{d_2}{q_2(2,s)}. \end{cases} \quad \ldots(6)$$

By comparing equations (3) and (6), there are four scenarios to consider:

(i) If $\Delta v>\kappa_f$: then Firm 2 will choose to invest regardless of ω_1, because $\Delta v>\kappa_f$ implies $\beta[q_2(2,f)\Delta v-d_2]>(1-\beta)[q_2(2,f)-q_2(1,f)]\Delta u>0$, making the first payoff in (6) larger than that in (3).

(ii) If $\kappa_s<\Delta v\le\kappa_f$: then Firm 2 will choose to invest only when $\omega_1=s$ if $q_2(2,f)\Delta v-d_2<0$, while it will invest regardless of ω_1 if $q_2(2,f)\Delta v-d_2>0$.

(iii)If $\frac{d_2}{q_2(2,s)}\le\Delta v\le\kappa_s$: then Firm 2 will invest, pay no licensing fee, and be indifferent between the two options.

(iv) If $\Delta v<\frac{d_2}{q_2(2,s)}$, Firm 2 will not invest in either case.

Scenarios (i) and (ii) differentiate between these two options. If the benefit of getting the new technology for Firm 2—Δv—is sufficiently large, or if the new technology can be successfully developed with a sufficiently high probability even when the midterm

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outcome is a failure—$q_2(2,f)$ is large—then Firm 2 will invest in Phase II anyway. Otherwise, to stop the investment when getting a signal $\omega_1 = f$ is a better way to go.

3.2.2 *Firm 2's investment decision in Phase I: Early investment*

We now analyze the case where Firm 2 invests in Phase I, i.e., Case 1.

Case 1: $x_1 = x_2 = 1,\ y_1 = 1$

In this case, the contract specifies the licensing fee paid by Firm 2 without observing the signal ω_1, denoted by ϕ_e. If Firm 1 accepts this contract, it obtains:

$$\pi_1 = q_1(2)\{q_2(1,s)(u + \Delta u + \phi_e) + [1 - q_2(1,s)]u\}$$
$$+[1 - q_1(2)]\{q_2(1,f)(u + \Delta u + \phi_e) + [1 - q_2(1,f)]u\} - c_1 - c_2.$$

If Firm 1 rejects the contract, it will have to develop the technology by itself. Then Firm 1 obtains:

$$\pi_1 = q_1(1)\{q_2(1,s)(u + \Delta u) + [1 - q_2(1,s)]u\}$$
$$+[1 - q_1(1)]\{q_2(1,f)(u + \Delta u) + [1 - q_2(1,f)]u\} - c_1 - c_2 \equiv \sigma_1''.$$

As for Firm 2, if it accepts the contract, it obtains:

$$\pi_2 = q_1(2)\{q_2(1,s)(v + \Delta v - \phi_e) + [1 - q_2(1,s)]v\}$$
$$+[1 - q_1(2)]\{q_2(1,f)(v + \Delta v - \phi_e) + [1 - q_2(1,f)]v\} - d_1.$$

If Firm 2 instead rejects it, it has only $v \equiv \sigma_2''$ again.

The Nash bargaining problem for solving the optimal ϕ is:

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$$\max_{\phi_1}\ (\pi_1-\sigma_1'')^{\beta}(\pi_2-\sigma_2'')^{1-\beta}$$

$$=\{[q_1(2)-q_1(1)][q_2(1,s)-q_2(1,f)]\Delta u$$

$$+\left[q_1(2)q_2(1,s)+\left(1-q_1(2)\right)q_2(1,f)\right]\phi_e\}^{\beta}$$

$$\times\left\{\left[q_1(2)q_2(1,s)+\left(1-q_1(2)\right)q_2(1,f)\right](\Delta v-\phi_e)-d_1\right\}^{1-\beta}\ \ldots(7)$$

The first-order condition is:

$$\beta\left\{\left[q_1(2)q_2(1,s)+\left(1-q_1(2)\right)q_2(1,f)\right](\Delta v-\phi_e)-d_1\right\}$$

$$=(1-\beta)\ \{[q_1(2)-q_1(1)][q_2(1,s)-q_2(1,f)]\Delta u+\left[q_1(2)q_2(1,s)+\left(1-q_1(2)\right)q_2(1,f)\right]\phi_e\}.$$

The Nash bargaining solution is:

$$\phi_e^*=\frac{\beta\{\left[q_1(2)q_2(1,s)+\left(1-q_1(2)\right)q_2(1,f)\right]\Delta v-d_1\}-(1-\beta)\{[q_1(2)-q_1(1)][q_2(1,s)-q_2(1,f)]\Delta u\}}{q_1(2)q_2(1,s)+\left(1-q_1(2)\right)q_2(1,f)}\equiv\tilde{\phi}_e.\ \ldots(8)$$

Therefore, we have the following Lemma:

Lemma 3. *If the equilibrium is one where* $x_1=x_2=1$, *and* $y_1=1$, *then the optimal licensing fee under Nash bargaining is* $\phi^*=\tilde{\phi}_e>0$ *if* $\Delta v>\kappa_e$, *and* $\phi_e^*=0$ *if* $\Delta v\leq\kappa_e$, *where* $\kappa_e=\frac{(1-\beta)\{[q_1(2)-q_1(1)][q_2(1,s)-q_2(1,f)]\Delta u\}+\beta d_1}{\beta\left[q_1(2)q_2(1,s)+\left(1-q_1(2)\right)q_2(1,f)\right]}$.

By substituting the optimal licensing fee into Firm 2's payoff, we have:

$$\pi_2=q_1(2)\{q_2(1,s)(v+\Delta v-\phi_e^*)+[1-q_2(1,s)]v\}$$

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$$+[1-q_1(2)]\{q_2(1,f)(v+\Delta v-\phi_e^*)+[1-q_2(1,f)]v\}-d_1.$$

$$=\begin{cases} v+(1-\beta)\{[q_1(2)q_2(1,s)+\big(1-q_1(2)\big)q_2(1,f)]\Delta v-d_1\} \\ \qquad +(1-\beta)\{\{[q_1(2)-q_1(1)][q_2(1,s)-q_2(1,f)]\Delta u\}\}, & \text{if } \Delta v>\kappa_e, \\ v+[q_1(2)q_2(1,s)+\big(1-q_1(2)\big)q_2(1,f)]\Delta v-d_1, & \text{if } \frac{d_1}{q_1(2)q_2(1,s)+(1-q_1(2))q_2(1,f)}\le\Delta v\le\kappa_e, \\ v & \text{if } \Delta v<\frac{d_1}{q_1(2)q_2(1,s)+(1-q_1(2))q_2(1,f)}. \end{cases} \quad \cdots (9)$$

Like the previous cases, when Δv is sufficiently large, Firm 2 is willing to invest and pay a positive licensing fee. If Δv is moderate, it will still invest but pay no fee. If Δv is too small, it would rather not invest.

3.3 Comparison between Early and Later Investments

As we discussed in the previous sections, if Δv is sufficiently large, or if $q_2(2,f)$ is large, Firm 2 is willing to invest in Phase II. It implies that Firm 2 can decide whether to invest or not based on the outcome of Phase I if it delays its investment. Upon receipt of the information of the result of Phase I, Firm 2 will better evaluate the probability of success for the innovation project owned by Firm 1 and make an investment decision accordingly. In other words, this is the advantage of a later investment, which enables Firm 2 to make an investment decision based on the outcome of Phase I to mitigate the risk. Nevertheless, delaying investment would force Firm 2 to compete with more competitors to bid for the license contract with Firm 1 if the outcome of Phase I is positive. Firm 2's bargaining power to negotiate a licensing fee with Firm 1 would also be shrunk accordingly.

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On the other hand, early investment allows Firm 2 to secure the market share ahead to its competitors. Additionally, if Δv is sufficiently large, Firm 2 is even willing to pay a positive licensing fee to Firm 1, and Firm 2 will pay less licensing fee than later investment since its bargaining power in early investment will be stronger than later investment due to more limited competitiveness. However, an early investment puts Firm 2 into an uncertain situation to make an investment decision without the information of the previous stage. It will inevitably generate more uncertainty for Firm 2 to evaluate the probability of success of Firm 1's project in Phase I.

After comparing the pros and cons of early and later investments, our next question is: what is the optimal timing of investment for Firm 2 and under which circumstances? We argue that an early investment is preferable for Firm 2 if Firm 2 is a "large firm" with higher market capitalization in the following sections.

3.4 The Optimal Timing of Investment

In this section, we would like to discuss under which circumstances Firm 2 want to invest early in Phase I. We have argued that when $\Delta v > \kappa_f$, if Firm 2 wants to invest in Phase II, it prefers to invest regardless ω_1. Similarly, if $\Delta v > \kappa_e$, Firm 2 will invest in Phase I and pay a positive fee. By focusing on the case where $\Delta v > \max\{\kappa_f, \kappa_e\}$, we can compare Firm 2's expected payoff specified in the first terms of equations (6) and (9). We have the following results:

Proposition 1. *Firm 2 prefers to invest early in Phase I if*

$$\{[q_1(2) - q_1(1)][q_2(1,s) - q_2(1,f)] - \alpha\}(\Delta v + \Delta u) > d_1 - d_2, \quad \dots (10)$$

where $\alpha = q_2(2,\omega_1) - q_2(1,\omega_1)$.

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In order for equation (10) to hold, it requires the left-hand side (LHS) is positive, i.e., $[q_1(2) - q_1(1)][q_2(1,s) - q_2(1,f)] > \alpha$, which means that the gain in the probability of obtaining a successful outcome because of Firms 2's investment in Phase I is larger than that if Firm 2 invests in Phase II. Consider that Firm 1 accepts the licensing contract in the case of Firm 2's investment in Phase I, its payoff is, as mentioned above:

$$\pi_1 = q_1(2)\{q_2(1,s)(u + \Delta u + \phi_e) + [1 - q_2(1,s)]u\}$$

$$+[1 - q_1(2)]\{q_2(1,f)(u + \Delta u + \phi_e) + [1 - q_2(1,f)]u\} - c_1 - c_2.$$

If Firm 1 rejects it, it obtains:

$$\pi_1 = q_1(1)\{q_2(1,s)(u + \Delta u) + [1 - q_2(1,s)]u\}$$

$$+[1 - q_1(1)]\{q_2(1,f)(u + \Delta u) + [1 - q_2(1,f)]u\} - c_1 - c_2 \equiv \sigma_1''.$$

From Firm 1's payoffs in Firm 2's early or later investment, we could observe that if Firm 1 accepts the contracts no matter which stage Firm 2 invests in, it can obtain a fixed licensing fee and a higher probability of success for its middle and final outcomes. In this game, Firm 1's dominant strategy is to accept the contract whenever Firm 2 makes its investment. Thus, the equilibrium exists in this case when Firm 2 invests in Phase I under the conditions below:

$$[q_1(2) - q_1(1)][q_2(1,s) - q_2(1,f)] > q_2(2,\omega_1) - q_2(1,\omega_1).$$

Furthermore, Proposition 1 indicates an interesting observation. As long as $[q_1(2) - q_1(1)][q_2(1,s) - q_2(1,f)] > \alpha$, equation (10) implies that if $\frac{\Delta v}{d_1 - d_2}$ is sufficiently large, early investment is preferable. The nominator is the net return of the

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investment, and the denominator is the cost of investment. This value can be interpreted as "market capitalization rate". A higher capitalization rate indicates a higher level of tolerance for investment with no return, while a lower rate indicates lower tolerance for such uncertainty. This suggests that large firms—those with greater market capitalization—are more likely to pursue early licensing deals. Their ability to tolerate higher uncertainty and absorb potential losses allows them to act before full information is available, securing a competitive edge. In the following chapter, we test this proposition empirically using a dataset of licensing transactions in the biopharmaceutical industry.

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Chapter 4 Empirical Model

To empirically assess the relationship between a licensee's firm size and the timing of licensing decisions, this chapter outlines the empirical model, data sources, sample construction, and variable definitions and examines whether and to what extent a larger market capitalization of licensee relates to early licensing.

4.1 Data

The source of data for this research is from *GlobalData*, which covers over 4000 licensing deals in the biopharmaceutical industry with various market variables including market capitalization, deal stage, enterprise value, operating profits, deal value and revenue. To match the market variables, this research draws the samples from 4000 licensing agreements between 2013 to 2018 which possess both market capitalization and deal stage, and the matched samples of licensing deals are reduced to 1150. Moreover, this paper categorizes various deal stages from discovery, pre-clinical, phase I, phase II, phase III to marketed stage and labels each of them as from 1 to 6 in order respectively. In doing so, it transforms different deal stages to non-continuous numbers for each phase of new drug development. Table 1 shows the descriptive statistics of the data set for licensing deals. The unit of these variables are United States million dollars.

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Table 1: Descriptive Statistics of the Sample

Variable	Obs	Mean	Std. Dev.	Min	Max
DealValue	606	248.439	469.194	.01	4065
Revenue	1140	11523.022	22810.32	-32.93	100330
Profit	1144	2958.985	7216.377	-2546.2	36551
MarketCap	1150	41264.995	91572.948	.01	567306
EnterpriseValue	959	50576.109	102358.21	-1894.85	575867
DealStage	1150	3.098	1.672	1	6

From the descriptive statistics of the data set, we can conclude although deal value seems to be related to deal stage, it is the consequence of licensing, not the cause of licensing. Deal value is therefore not our first choice of key independent variable in the empirical model.

4.2 Estimation

The deal stage, as described above, is a non-continuous and ordered variable which represents a different period of new drug development with each number from 1 to 6 on such variable. When drug development is closer to being marketed, the development cost will become higher, and design of human subject clinical trial will be more complicated. Wouters, McKee and Luyten (2022) indicated that from 63 of 355 new therapeutic drugs and biologic agents approved by the US Food and Drug Administration between 2009 and 2018, the estimated median capitalized research and development cost per product was $985 million, counting expenditures on failed trials. To depict the deal stage more precisely, this paper treats each of these respective stages as a “period” and assume that a similar trade-off made by the licensee between signing in various stages. As we learned from current literature for licensing research, an ordered logit model is a better fit to address this kind of ordered variable (Allain, Henry and Kyle 2016).

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The ordered logit model is a regression model for variables which are ordinal rather than continuous. It constructs upon cumulative probabilities of the response variable and is used in various circumstances, such as air transport service quality performance, life assessment and expectations and tourist satisfaction assessment (Williams 2016). For example, the answer to the question on how satisfied a person is with her quality of life can range from 1 to 10, with one being very dissatisfied and ten being very satisfied, which is naturally ordinal (Grilli and Rampichini 2014).

In this research, the deal stage is an ordinal variable, and we aim to investigate whether a large firm will buy ideas early with the ordered logit model. We assume that when a licensee's market capitalization is higher, the probability of licensing deal at early stage is higher. The regression model is denoted as below, where j means ordinal scale of various deal stage, x means a licensee's market capitalization, and Y represents the deal stage.

$$\log\frac{P(Y \leq j)}{P(Y > j)} = logit\big(P(Y \leq j)\big) = ax + \beta_j \quad \dots (11)$$

To mitigate concerns about omitted variable bias, we include "Profit" and "Revenue" as control variables since the profit or revenue would also be likely to impact on the time of licensing. The use of firm size as a key independent variable, rather than proxies such as revenue or profit, reduces endogeneity concerns related to short-term business cycle fluctuations.

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4.3 Empirical Results

We use the ordered logit model to regress the licensee's revenue, profit and market capitalization with deal stage, and Table 2 denotes the result of regression as below.

Table 2: The Regression Result for Licensee's Market Cap and Deal Stage

DealStage	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Revenue	0.0000105	0	1.04	.297	0	0	
Profit	-0.0000466	0	-1.55	.12	0	0	
MarketCap	-0.00000194	0	-2.25	.025	0	0	**
cut1	-1.861	.088	.b	.b	-2.033	-1.689	
cut2	-.012	.065	.b	.b	-.139	.115	
cut3	.373	.066	.b	.b	.244	.502	
cut4	1.072	.073	.b	.b	.929	1.215	
cut5	1.669	.087	.b	.b	1.499	1.84	
Mean dependent var		3.105	SD dependent var			1.676	
Pseudo r-squared		0.006	Number of obs			1138	
Chi-square		21.055	Prob > chi2			0.000	
Akaike crit. (AIC)		3763.570	Bayesian crit. (BIC)			3803.867	

*** $p<.01$, ** $p<.05$, * $p<.1$

The regression results in Table 2 demonstrate that one unit increase of licensee's market cap increases -0.00000194 of log odds likelihood in the higher level of deal stage, given all the other variables in the model are held constant. A negative relationship between the licensee's market cap and deal stage could be observed in Table 2. The coefficient on market capitalization is statistically significant at the 0.5% level, confirming the hypothesis that larger firms are more likely to engage in early-stage licensing.

To present a sharper comparison between large firms and small firms, we categorize the firms with top 20% of market cap (the "Top 20% firms") and the firms with bottom 20% of market cap (the "Bottom 20% firms") as two separate variables and utilize the ordered logit regression to generate the Table 3 as below.

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Table 3: The Regression Result of Market Cap for Top 20% and Bottom 20% Firms

DealStage	Odds Ratio	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Revenue	1	0	1.51	.131	1	1	
Profit	1	0	-2.03	.042	1	1	**
large_firm	.479	.105	-3.35	.001	.311	.737	***
small_firm	.603	.055	-5.50	0	.504	.722	***
cut1	-2.007	.069	.b	.b	-2.142	-1.871	
cut2	-.146	.053	.b	.b	-.25	-.043	
cut3	.243	.053	.b	.b	.14	.347	
cut4	.951	.057	.b	.b	.84	1.063	
cut5	1.554	.066	.b	.b	1.425	1.683	

Mean dependent var	3.105	SD dependent var	1.676
Pseudo r-squared	0.010	Number of obs	2276
Chi-square	69.524	Prob > chi2	0.000
Akaike crit. (AIC)	7482.809	Bayesian crit. (BIC)	7534.381

*** *p*<.01, ** *p*<.05, * *p*<.1

In Table 3, we demonstrate that the odds of the high category of deal stage versus the low and middle categories of deal stage are 0.479 times greater for large firms and 0.603 times for small firms when one unit of licensee's market cap increases. Furthermore, the difference in odd ratio between large firms and small firms is 0.124, which means the odds ratio of small firms for later deal stage is higher than large firms when the licensee's market cap arises for one unit of change.

In addition, we further categorize the firms with top 40% of market cap (the "Top 40% firms") and the firms with bottom 40% of market cap (the "Bottom 40% firms") to regress with ordered logit model for examining whether the regression result for firms with first and last 40 percent of market cap is still consistent with the trend as exhibited as above. The regression result in Table 4 indicates that the odds of the high categories of deal stage versus the low and middle categories of deal stage for Top 40% firms are 1.794 times greater, while 0.731 times greater for Bottom 40% firms.

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Table 4: The Regression Result of Market Cap for Top 40% and Bottom 40% Firms

DealStage	Odds Ratio	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Revenue	1	0	-0.85	.394	1	1	
Profit	1	0	-0.69	.488	1	1	
large_firm_40	1.794	.196	5.36	0	1.449	2.222	***
small_firm_40	.731	.067	-3.43	.001	.611	.874	***
cut1	-1.842	.073	.b	.b	-1.985	-1.699	
cut2	.02	.059	.b	.b	-.095	.136	
cut3	.412	.059	.b	.b	.295	.528	
cut4	1.126	.064	.b	.b	1	1.252	
cut5	1.735	.072	.b	.b	1.594	1.877	

Mean dependent var	3.105	SD dependent var	1.676
Pseudo r-squared	0.012	Number of obs	2276
Chi-square	79.348	Prob > chi2	0.000
Akaike crit. (AIC)	7466.536	Bayesian crit. (BIC)	7518.108

**** p<.01, ** p<.05, * p<.1*

Besides, we further summarize the means for Top 20% firms and Bottom 20% firms and apply the ordered logit regression to predict the probability of each deal stage with a new dummy variable. The difference between the probability of Top 20% firms and Bottom 20% firms is also calculated along with the prediction of probability. After summarizing the predicted probability for Top 20% firms and Bottom 20% firms as well as the difference between them at each deal stage, the empirical result is displayed as below in Table 5. From the section of Table 5, we could observe easily that the probability for large firms to buy ideas at an early stage is higher than that of small firms, and the difference between Stage 1 and Stage 2 is 0.066, while it is 0.052 between Stage 2 and Stage 3.

Table 5: Summary of Predicted Probability for Large Firms and Small Firms

Deal Stage	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5
Large Firm	.2009148	.41609877	.08589141	.12302003	.07029289
Small Firm	.13435988	.3642728	.09495313	.15189575	.09656426
Difference	.06655492	.05182597	-.00906172	-.02887572	-.02627137

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To summarize, we find empirical evidence that the timing of licensing relates to the licensee's market cap that the probability of licensing in later stage decreases when licensee's market cap increases. More specifically, this empirical study builds up three patterns shown in the data on the relationship between timing of licensing and licensee's market cap:

1. An increase in licensee's market cap brings early licensing for all the samples very slightly.
2. An increase in licensee's market cap brings early licensing for both large firms with top 20% market cap and small firms with bottom 20% and 40% market cap, but will delay licensing for large firms with top 40% market cap; and
3. The likelihood for early licensing of the top 20% large firms is higher than the bottom 20% small firms as the licensee's market cap increases.

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Chapter 5 Discussion

5.1 Interpretation of Main Findings

This chapter discusses the empirical findings presented in Chapter 4 and interprets them in light of the theoretical model developed earlier. The empirical results confirm the theoretical prediction that larger firms are more likely to engage in early-stage licensing. This finding is consistent with the notion that firms with greater financial capacity can better tolerate the uncertainties associated with early-stage innovations. Larger firms are able to absorb potential failures and capitalize on successful innovations by committing resources at an earlier phase, thereby gaining a competitive edge over their rivals.

Overall, these findings underpin the important role of firm size in shaping licensing behaviors. For licensees, firm size offers a strategic advantage in acquiring early-stage innovations. Firms with substantial financial and organizational resources can capitalize on opportunities earlier, often gaining access to promising technologies before competitors. Smaller firms may need to pursue collaborative strategies, such as alliances or co-development agreements, to mitigate their relative disadvantage in early-stage licensing.

5.2 Contributions to Literature

This study contributes to the literature on technology markets by emphasizing the significance of licensee characteristics—particularly market capitalization—in determining licensing behavior. While previous research has examined factors such as

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technological uncertainty and project stage, this paper highlights the financial capacity of the licensee as a key determinant of licensing timing.

By combining a two-stage sequential investment model with empirical analysis, this research provides a more comprehensive understanding of investment behavior in licensing markets, particularly in high-risk industries like biopharmaceuticals. The next chapter concludes the study and outlines directions for future research.

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Chapter 6 Conclusion

This study investigates how the size of a licensee influences the timing of licensing decisions in the biopharmaceutical industry. By developing a two-stage sequential investment model and conducting an empirical analysis based on licensing transactions, we demonstrate that larger firms are significantly more likely to engage in early-stage licensing. Firms with greater financial capacity are better equipped to absorb the uncertainties and risks inherent in early-stage innovations, enabling them to secure strategic advantages through early investment.

The empirical findings align with the theoretical model, reinforcing the notion that firm-level financial characteristics are critical determinants of strategic behavior in the market for technology. In particular, larger firms, as measured by market capitalization, exhibit a greater propensity to commit to early-stage projects compared to their smaller counterparts.

This research contributes to the growing body of literature on licensing and innovation commercialization by highlighting the role of financial capacity on the demand side of technology markets. It also offers practical implications for licensees in formulating licensing strategies, which they can leverage firm size to compete more effectively for early innovation opportunities.

Nonetheless, this study has some limitations. The analysis focuses exclusively on the biopharmaceutical industry, which may limit the generalizability of the findings to other sectors with different innovation and commercialization dynamics. In addition, while market capitalization is a widely used proxy for firm size and financial capacity, it

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may not fully capture other aspects of organizational capability relevant to licensing decisions.

Future research could explore additional indicators of firm strength, such as R&D investment intensity or technological expertise, and examine whether similar patterns hold in other industries or across different geographic markets. Further investigations could also analyze how other factors, such as firms' prior licensing experience or strategic motivations, influence the timing and success of licensing deals.

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